THE AËRONAUTICAL JOURNAL

JULY, 1908.

The Aëronautical Journal.

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NOTICES OF The Aëronautical Society of Great Britain.

At a Council Meeting of the Aëronautical Society of Great Britain, held at 53, Victoria Street, Westminster, on May 11th, 1908.

1. The following gentleman was elected a member of the Council:

MR. W. F. REID, C.E.

To date April 28th, 1908.

2. The following gentleman was elected President of the Society, for a period of three years:

MR. E. P. FROST, D.L. (Cambs.).

To date May 2nd, 1908.

3. The following gentlemen were elected members of the Society:

MR. HERBERT CHATLEY.
MR. WILLIAM BENNETT.
MR. HERBERT EDWARD BROWN.
MR. THOMAS O'BRIEN HUBBARD.

To date May 11th, 1908.

4. It was decided to have an outdoor meeting of the Society during the month of July, 1908, if suitable arrangements can be made. The exact date when fixed, will be duly notified to members, by circular.

5. It was decided to award the Society's medal to:

(1) The author of the best paper published in the Journal during the year 1908, provided that the Council considers the paper suitable for such an award.

(2) Members doing useful research work for the benefit of the Society. (No special period was fixed for this award.)

MISCELLANEOUS NOTICES.

1. It is notified for the general information of members that a "London Balloon Company, Territorial Forces," is now in process of formation.

The general conditions of service are: Term of enlistment, 4 years. Age limits, 17 to 35 years. Drills per annum, about an evening once a fortnight.

Annual training in camp, not less than 8 days, or more than 15 days.

Members requiring fuller information about the Company should apply to

H. E. HOLTORP, Esq.,
The London Balloon Company,
Drill Hall, Regency Street,
Westminster, S.W.

2. The following books and publications have been presented to the Library:

By COLONEL TROLLOPE (late Grenadier Guards).
"La Conquête de l'Air" (current numbers).

By M. J. ARMENGAUD (Jne.).
"La Problème de l'Aviation et sa solution par l'Aéroplane."

By HORATIO PHILLIPS, ESQ.
"Mechanical Flight, etc."

By H. F. LLOYD, ESQ.
Photo-Postcards of Flying Machines.

3. The Press cuttings supplied to the Society during June quarter are now available for issue. Any member who wishes to have them should apply to the Hon. Secretary on July 20th, 1908. They will be given to the first applicant.

4. Members and others contributing to the Journal are requested to kindly observe the following rules when drawing up their MSS.:

(*a*) Write on one side of the paper only.

(*b*) Leave a margin one inch wide on the left-hand side.

(*c*) Draw diagrams, etc., on very white paper with very black ink, as this greatly simplifies reproduction.

(*d*) Forward their communications to the Hon. Secretary at least 14 days previous to the date of the meeting at which the paper is to be read. Papers containing diagrams, sketches, etc., which it is required to show on lantern slides, should be sent in as early as possible.

GENERAL MEETING.

The second meeting of the 43rd session of the Aëronautical Society of Great Britain was held at the Royal United Service Institution on May 27th, 1908. The chair was taken by the President of the Society, Mr. E. P. Frost, D.L. (Cambs.).

The PRESIDENT: Ladies and Gentlemen, In the name of the Aëronautical Society of Great Britain—the oldest Aëronautical Society in the world—I beg to extend to our foreign visitors a very cordial welcome, and especially to those gentlemen who have come here this evening to assist us at this our 43rd Session. We rejoice to find that others of foreign lands are in the same line of thought and action as ourselves, and we hope that such joint and friendly action may bring about aërial navigation that may astonish the world. I do not mean, of course, such disasters that have recently happened in California, which we deeply regret, but I trust these failures may only lead later on to success. I am sure we all wish to offer to Mons. Farman and Mons. Delagrange and others our congratulations and our thanks for so courageously and so openly being pioneers of schemes towards the achievements we have at heart. I beg leave also to thank the engineers and motorists for the very powerful and light engines that they offer us now. Such equipment, such engines, that neither love nor any amount of money could have brought us twenty or thirty years ago, when I was busy on a big machine. Gentlemen, these friendly international gatherings should result in great things for the benefit of all. But, at the same time, we devise means of throwing explosives from above to annihilate each other's armies, and, I suppose, as long as there is any chance of any fighting we must do so. But I cannot let this opportunity pass without hoping that these international gatherings will not only lead to aërial navigation without the need of explosive throwing, but also to a scheme little talked about, but a great deal, perhaps, thought about, to bring about an international union that will do away with the necessity of fighting amongst civilised nations, and do away with the necessity of costly, ever increasing costly, armaments. But as we have many papers to go through this evening I must detain you no longer, and I will call upon the gentleman who will read the first paper.

In the absence of the author, the Hon. Secretary read the following paper:

The Art of Flying.

By V. SILBERER, President of the Vienna Aëro Club.

Seven years ago, when the first number of my "Wiener Luftschiffer-Zeitung" (Vienna Journal for Aëronauts) appeared, considerable surprise was evinced in some quarters by the sub-heading, "Special Journal for Aëronautics and the *Art* of Flying."

"The art of flying?"

Well, to-day there are but few who do not admit that the words were correctly chosen, though the title at that time may have been somewhat premature. To-day not one of those, perhaps, who, with an attentive eye, have followed the many recent attempts at aviation, will deny the fact that "Flying" is an art indeed.

It is, however, an art that is still in its very earliest infancy, an art whose greatest artists are but too well aware that they have yet everything to learn and that in spite of the jubilant cry of theoreticians about the problem being solved.

But the most remarkable point in the matter is that the great progress and success attained in so short a time in aviation and with dirigible balloons is not attributable to the conception of aëronautics or aviation at all, but to the manufacture of engines for motor cars. These modern light motors were originally constructed to meet the exigencies of automobilism, but are at present also employed for carrying out the ideas of aëronauts and aviators in the domain of dirigible balloons and flying machines.

If our poor old Kress here in Austria, at the time when he was in a position to spend the money needful for his "Kite-flyer," had been able to obtain one of the modern light motors, his labours and attempts would no doubt have been rewarded with greater success.

The admirably light motors with which aviators are at present provided may assuredly be regarded as the chief incentive to the construction of numerous flying machines which, whatever may be said against them, enable their inventors and constructors to effect real flights, though ever so short and uncertain, ever so perilous and unreliable.

In all these attempts and trials, however, it will be seen that a motor, whatever its weight may be, and a flying machine or aviator, however well constructed and furnished with such a motor, will not suffice to enable a mechanical contrivance to wing its flight successfully, but that there is a third and all-essential condition, and that is—*the art of flying*, which he who makes aviatic attempts of this kind will have to learn at the daily and hourly hazard of his sound limbs and life, even with the most promising machine.

This art, more than any other, will require active energy, courage, decision of purpose, a quick eye and clearness of judgment, utmost presence of mind; also an enormous amount of patience, assiduity and perseverance, and finally, efficient training and physical dexterity.

The practical aviator must be endowed with a portion of these qualities at the very outset of his experiments, namely, all the above-cited moral virtues, in addition to general manual skilfulness and bodily aptitude. Adroitness in managing the technical contrivances and an accurate knowledge of the working capacity of his machine in the air, the peculiarities of its movement, its reaction on all possible influences while flying, the influence exercised by the aviator's different operations upon the action of the machine, the manner of steering, the force needed for the different operations, the innumerable points to be taken into account; all these will, only by long-continued, indefatigable practice on the part of numerous incipient aviators, lead to such experience as can be embodied in general principles of aviation, and which will save much trouble and risk to future beginners.

These pioneers and truthfinders, however, who are now exploring this alluring "terra incognita," from which as yet no beacon of practical experience is sending forth its cheering light, have set themselves a sky-aspiring task as stupendous as it is difficult.

Even the trials and preliminary practice hitherto show to what extreme dangers to limbs and lives the disciples of the fascinating art of aviation must expose themselves. Even now, when—most reasonably—they are only trying to glide cautiously along on quite even ground, at a height of but a few metres, downfalls of the gravest and most formidable kind occur. More than one of the bold aspirants to the realms of thin air has encountered accidents in which his life was only saved as by a miracle. But how will it be when once they go beyond the first preliminary attempts? When they are placed before the task of passing from these incipient experiments made, so to say, in the workshop, on the even, unobstructed practising ground, to the infinitely graver and more difficult evolutions above the ordinary pathways of earth, at a height which enables us to rise above terrestrial obstacles, to soar above trees, forests, buildings, cities? What peril of life to the aviator if the motor should stop or any part of its propelling mechanism fail!

By far the majority of the apparatus now used for experiments, such as all

those constructed with a cellular or box-like arrangement, all of which maintain themselves in air only so long as they are propelled with great velocity, do not sink slowly when the motor stops, but are precipitated to the ground like a lump of lead.

How many, then, will be the accidents, how great will be the loss of life, before sufficient experience has been acquired for producing an apparatus which does not capsize or lose its equilibrium under any circumstances?

And in the event of a sudden failing of the propelling force, of the steerage or other vital part of the mechanism, will it be possible in these trials with the present apparatus of small superficies, at some considerable height, to effect a smooth and safe landing and to preclude catastrophes through contingencies of any kind?

Let us, then, pay homage to the men who, with iron energy and at the constant risk of their lives, devote their services to the development of aviation and to the acquisition of this newest but most serious and perilous art—the art of flying!

The PRESIDENT: Is there any gentleman who wishes to say anything on the paper we have just heard? (No response.) We will pass on to the next paper. In the absence of the author, the Hon. Secretary read the following paper:

Recent Aëronautical Progress in the United States.

By O. CHANUTE.

The public attitude in the United States in 1906 and 1907 concerning aërial navigation has been one of expectancy and apathy. The announcements of the marvellous success achieved by Wright Brothers, which every investigation seemed to confirm, must have deterred many searchers from experimenting at all, until they knew how much remained to be accomplished in aviation.

In ballooning very little new work was undertaken. The United States Government having neglected aëronautics until quite lately, the only reward to be expected by inventors was from public exhibition, and for this only small sizes of dirigible balloon were within the means of promoters. Hence the speeds (depending as they do upon the power of the motor which it is possible to lift) have not been sufficiently great to overcome the wind upon all occasions. A number of dirigibles have, nevertheless, been shown in action; those of Mr. Stevens, Mr. Knabenshue, and Mr. Baldwin, mostly in connection with amusement parks, but fresh public interest in the subject was excited by the international balloon race from St. Louis on October 21st, 1907, of which full information has been published in many journals. This public interest, together with the reports of the great progress and activity of the European Governments, spurred the United States Signal Corps to issue invitations on December 17th, 1907, for proposals for dirigible balloons, to be opened January 15th, 1908.

Seven bids were received, but as they proved unacceptable, new proposals were called for, with some modifications, to be opened February 15th, 1908. Eleven proposals were then received, and an award was made to Thos. F. Baldwin for a dirigible balloon to be delivered in 150 days at a price of £1,350. This is now being built. It is to be 84 feet long by a diameter of 16 feet and a capacity of 17,000 cubic feet. The motor is to be of 30-horse power, 4 cycle, 4 cylinders of cast iron copper-jacketed, water cooled, and with magneto ignition, built by Curtiss. The probable weight is 200 pounds, and the speed required is 20 miles per hour. While this dirigible will be quite inferior in size and in speed to those now existing in Europe, it will be of value in training a corps of aëronauts for the management of larger vessels, perhaps to be built upon lines of less resistance, as indicated by some recent achievements in water navigation.

Meanwhile Aëro Clubs have sprung up like mushrooms all over the country. The leading one still is the Aëro Club of America in New York, which was organised in 1905. It has held several exhibitions, has promoted the publication of an interesting book, "Navigating the Air," the establishment of a correspondence School of Aëronautics by Mr. Triaca, and an effort is now being made in connection with the Club to raise a fund of £5,000 to be offered in prizes for Aviation.

In St. Louis and in Chicago local aëro

clubs propose to organise balloon races to be held in 1908. In these and other cities, members are encouraged to engage in the sport by owning and riding balloons themselves, and it remains to be seen how long the enthusiasm will last.

Two monthly Aëronautical Magazines have been started, one in New York and one in St. Louis, but it is yet to be ascertained how well they will be supported.

The Jamestown Exposition of 1907 organised an aëronautical exhibit which amounted to but little, as well as an Aëronautical Congress which brought out few papers, but searchers have been building apparatus upon various designs to be experimented with in the summer of 1908.

The most distinguished of these is Dr. Alexander Graham Bell, the inventor of the Telephone, who has been experimenting with his tetrahedral kite. He tested on December 6th, 1907, his gigantic man-lifting kite "Cygnet," consisting of 3,393 wing cells, presenting 1,966 square feet of oblique surfaces, and weighing with the floats and passenger an aggregate of 600 pounds. This was towed into the middle of a lake and raised against a wind of 21 miles an hour by a tug-boat. It exhibited that perfect stability which all previous experiments indicated, and upon the wind's dying away it descended gently from a height of 168 feet, but was broken on striking the water. It is to be tested again during the summer of 1908 with a view to eventually applying a motor. There is no question as to the automatic equilibrium of this form of apparatus, but it is possible that the inferior lifting power of the oblique surfaces and the resistance of so many front edges will make the design less favourable for a flying machine than other forms.

Dr. Bell then generously provided the means (he gives the credit to his wife) and organised the so-called "Aërial Experiment Association" with its headquarters at Hammondsport, New York, to give his assistants a chance to experiment their own ideas. The first result was the construction of the motor-driven aëroplane "Red Wing," chiefly designed by Lieutenant T. Selfridge, which made its trial trip on sleigh runners on the ice of Lake Leuka on March 9th, 1908. It is a double-decked apparatus 43 feet across, the surfaces being arched both fore and aft and from tip to tip; the upper aëroplane being bowed downward somewhat in the attitude of the gull and the lower aëroplane, which is 6 feet shorter, being bowed upward somewhat to the attitude of the vulture when soaring. The total surface is 386 square feet and the total weight, including the aviator, is 570 pounds. It is driven by a Curtiss motor of 40-horse power, actuating a screw propeller.

At the very first attempt the apparatus left the ice after travelling only 200 feet and flew a distance of 319 feet from the point where it left the ice to the point of descending. It alighted somewhat clumsily and broke one strut, this being the first public exhibition of the flight of a heavier-than-air machine in America. The melting of the ice prevented further experiments, but the machine was placed on wheels and a telegram announces that experiments were resumed on May 13th. The other assistants, Mr. F. W. Baldwin and Mr. I. A. D. McCurdy, are to have their innings later.

Mr. J. W. Roshon, of Harrisburg, Pennsylvania, has also built a motor-driven aëroplane, but only preliminary experiments have been made so far.

Mr. O. G. Luyties, of Baltimore, Mr. J. N. Williams, of Derby, Connecticut, and Mr. W. R. Kimball, of New York, are building helicopteres, while Mr. Israel Ludlow, Mr. G. A. Spratt, Mr. A. Q. Dufour, and Mr. L. J. Lesh are experimenting with gliding machines, the last-named being a 16-year-old lad of great promise, who has flown on a glider for 6 miles over the St. Laurence River towed by a motor boat.

The main interest, however, attaches to the pending United States Government tests of flying machines which are under contract for delivery next August. On December 23rd, 1907, the United States Signal Corps issued invitations for tenders, which produced much amazement. European and American journals have said that these specifications assume that flying machines are almost a usual method of transportation, and that the terms are so exacting as to seem unreasonable. The Signal Service officers answer that the specifications were drawn up after interviews with some of the inventors and merely

cover what they said that they could perform, while some clauses were added to prevent the Government's being trifled with, and that the tests will be conducted with judicious reason and liberality. More especially does this apply to the granting but three trials each for the speed test and the endurance test of one hour, which might be defeated on each occasion by some fortuitous and trifling circumstance.

However, under these specifications, no less than 41 proposals were received, but only three were found to comply fully with the requirements. Awards were accordingly made on February 8th, 1908, to the following bidders:

J. F. Scott, Chicago, Ill., price £200, delivery in 185 days.

A. M. Herring, New York, price £4,000, delivery in 180 days.

Wright Brothers, Dayton, O., price £5,000, delivery in 200 days.

Mr. Scott has since withdrawn his proposal, and Mr. Hering and Wright Brothers are building machines.

For about 15 years Mr. Herring has been continuously working towards a solution of the problem of Aviation, and the present undertaking is to bring either the fruition of all his endeavours or the defeat of all his hopes. He was assistant to Professor Langley in the building of his first steam flying models, and to Mr. Chanute in carrying on gliding experiments. Since 1897 he has been operating for himself, finding this more congenial than to experiment under the direction of others. He is said to have now produced two gasolene motors of 22-horse power each, weighing somewhat less than 21 pounds, and a new mode of automatic regulator to neutralise all the turmoils of the wind. Also a working model which is said to have flown 22 consecutive circular miles. He expects to obtain a speed of about 50 miles per hour with the machine which he is building for the Government, and has notified it that he will be ready to make the tests in June. It is to be earnestly hoped that they will not be disappointing.

The performances of Wright Brothers have been viewed with incredulity because of the mystery with which they have been surrounded in the hope of a rich money reward, yet it is now generally conceded that they have accomplished all that they have claimed, *i.e.*, to have made a first dynamic flight in 1903, to have mastered circular courses in 1904, making 105 flights, the longest of which was three miles, and to have obtained thorough control over their apparatus in 1905, making 49 flights, the longest of which was of 24 miles, consisting of 30 sweeps over a circular course at an average speed of 38 miles an hour. Since then they have made no flights, having been engaged in negotiations with a view to marketing their invention.

Now they have made a contract with the United States Government to furnish a flying machine under those formidable specifications. They set to work at once. They have built parts of more than one machine, so as to guard against bad breakages, and have returned to their old experimental grounds near Kitty Hawk, North Carolina. This is situated on a long sand spit, two or three miles wide, between the waters of Pamlico Sound and the Atlantic Ocean. It is about as inaccessible a spot near civilisation as can well be, being almost a desert, occupied by a few fishermen and a Government life-saving station. Near the camp is "Kill Devil Hill," a cone of drifted sand about 100 feet high, on which former gliding experiments were made.

Here the Wrights have established themselves and begun their practice, for it is only by strenuous practice that the mastery of the air is to be obtained. They are said to be proceeding with great caution, testing every part and peculiarity of the machine, the longest flight yet reported (May 14th, 1908) being eight miles, followed, however, by a serious breakage on landing, said to be due to a false manœuvre, in consequence of some change in the location of the levers which control the rudders. It is stated that the wreck was so complete that the parts will be shipped back to Dayton, Ohio, where the craft will be rebuilt.

The Wrights are understood to have until August 27th to deliver their machine to the Signal Corps for testing, so that there will be sufficient time to resume practice after the machine is repaired. Whether this practice will take place on the same ground or elsewhere is not known. The spot is very secluded, but the ubiquitous reporter has found

the camp and is sending "news," both true and untrue, to the great annoyance of Wright Brothers, from Manteo, a little town on Roanoke Island, the seat of Sir Walter Raleigh's first settlement in 1585. This is about six miles across from the camp.

An amusing struggle has resulted. The reporters are frantic for information, and the Wrights most determined that no description be given of their apparatus. It is probable that many contradictory cablegrams will have been received in Great Britain when the present paper reaches the Hon. Secretary.

Wright Brothers stand a fair chance of passing the tests and having their machine accepted. They may be defeated by some accident during the preliminary trials or the formal tests, but the present writer is sure that all the members of the Aëronautical Society of Great Britain will join him in the hope that the best of luck will attend the demonstration.

The PRESIDENT: The paper is open for discussion. Is there any gentleman who would like to say anything? (No response.) I will call upon Colonel Fullerton to read his paper.

Notes on the Phillips Flying Machine.

By COLONEL J. D. FULLERTON, R.E.

As Mr. Phillips is unable, through stress of work, to write an account of his machine, I have prepared a few notes about it, and he has kindly revised them.

The machine is of a quite unusual type, and the study of its design and general system of working will be found of great interest.

In order to understand the principles upon which it is based, it is desirable to first examine briefly the early experiments carried out by Mr. Phillips and the results obtained from them.

EARLY EXPERIMENTS.

In 1885 (see "Engineering," August 14th, 1885) he tested a number of surfaces of the types shown in Fig. 1. by fixing them in a sort of wind trunk, through which air could be passed at any required velocity. Assuming a fixed lift, he then measured the drift and velocity when the surface was inclined at the most favourable angle, and from the data thus obtained the following table was drawn up:

TABLE I.

Description of Form.	Velocity of Air. Ft. per sec.	Dimensions Inches.	Lift. Ounces.	Drift. Ounces.	Angle.
Plane.. ..	39	16 × 5	9	2·00	15°
No. 1.. ..	60	16 × 1¼	9	0·87	Small; not greater than 5°
,, 2.. ..	48	16 × 3	9	0·87	
,, 3.. ..	44	16 × 3	9	0·87	
,, 4.. ..	44	16 × 5	9	0·87	
,, 5.. ..	39	16 × 5	9	0·87	
,, 6.. ..	27	16 × 5	9	2·25	
Rook's wing	39	0·5 sq. ft.	8	1 00	

Mr. Phillips' explanation of the action of the air when passing over and underneath forms of the type above tested is as follows:

"The object of these blades (forms) is to deflect upward air that comes in con-

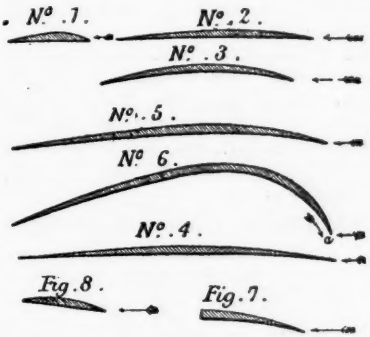


Fig. I.

tact with their forward edges or portions in such a way as to cause a partial vacuum to be created over a portion of the upper surface of the blade, thus aiding the air below to support the weight."—See Patent Specification, No. 13768 of 1884.

The general results of Mr. Phillips' experiments with a very large number of surfaces of different shapes may be summed up as follows:

1st. Slightly curved and arched surfaces of the types shown in the Figs. 1

and 8 have a far greater efficiency than flat ones.

2nd. Surfaces in which the width (perpendicular to the line of motion) is much greater than the length (in the line of motion) are much more efficient than surfaces in which these dimensions are reversed.

3rd. The maximum effect from any surface was obtained, when the amount of concavity of the lower side, and the corresponding convexity of the upper surface, bore a certain definite proportion to the velocity of the air current.

An inspection of Table I. shows that the best results were obtained with form No. 5 as with a velocity of only 39 ft. per sec.

$$\frac{\text{drift}}{\text{lift}} = \frac{1}{10{\cdot}34}$$

or, in other words, the lift was more than ten times the drift.

Mr. Phillips was not, however, satisfied with this, and continued his experiments. Eventually he designed some shapes, which gave a lift = 20 times the drift (see Fig. II.), and it is forms of this and similar types that he uses in his flying machines.

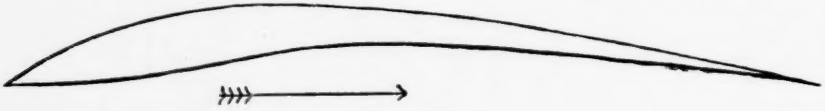


Fig. II

EXPERIMENTAL MACHINE.

TYPE 1893.

See Fig. III.

Patent No. 13768 of 1884.

Patent No. 20435 of 1890.

Patent No. 13311 of 1891.

The general construction of the machine was as follows:

General Dimensions.—Length, 25 feet; breadth, 22 feet; height, 11 feet; total weight, including 72-lb. load, 420 lbs. It was not intended to carry a passenger, but to show the principles of Mr. Phillips' invention. Lift per square foot, 3 lbs., and per B.H.P., 70 lbs.

Sustainers.—These consisted of 50 wood slats, something like the slats of a Venetian blind in shape, fixed in a steel frame, 22 feet long by 9½ feet in height. The slats themselves were 22 feet long, 1½ inches wide, curved in section to the peculiar shape advocated by Mr. Phillips. The area of the sustaining surface was 136 square feet, the slats being slightly inclined when the machine was in motion; total weight of the sustainers, 70 lbs.

Suspenders.—The sustainer was fixed to the car by wire guys, care being taken to have the frame truly vertical.

Car.—This was a sort of skeleton framework formed by two planks on edge. Just under the sustainer the planks were 3 feet apart; in rear the distance was 1½ feet, while in front the space between them allowed of the front wheel working easily in it. There were two other wheels, 1 foot in diameter, under the frame; weight, 60 lbs.

Motor.—An 8 to 9 I.H.P. compound steam engine, with coal fuel. The boiler was of phosphor-bronze, 1 foot in diameter and 1¼ feet in height. Steam pressure, 180 lbs.; revolutions, 400 per minute. Total weight, with fuel for about half an hour, 200 lbs.

Propulsion.—One 2-bladed screw, wing-shaped, in section; diameter, 6 feet; pitch, 8 feet; projected area, 4 square feet. The thrust, standing still, was 75 lbs., and was probably about 70 lbs. when in motion. The B.H.P. was about 6-H.P., and the efficiency of the whole very high.

Steering in a Vertical Plane.—There was no arrangement for this; see trials below.

Equilibrium Apparatus.—See trials below.

Rising and Landing.—See trials below.

Trials.—As it was not possible to put a passenger in the machine to control it, it was attached to a central post by wire guys and run round in a circle of 100 feet in diameter. The track consisted of wooden planking about 4 feet wide. The apparatus was started under its own steam. As the velocity increased, the pressure of air under the slats caused it

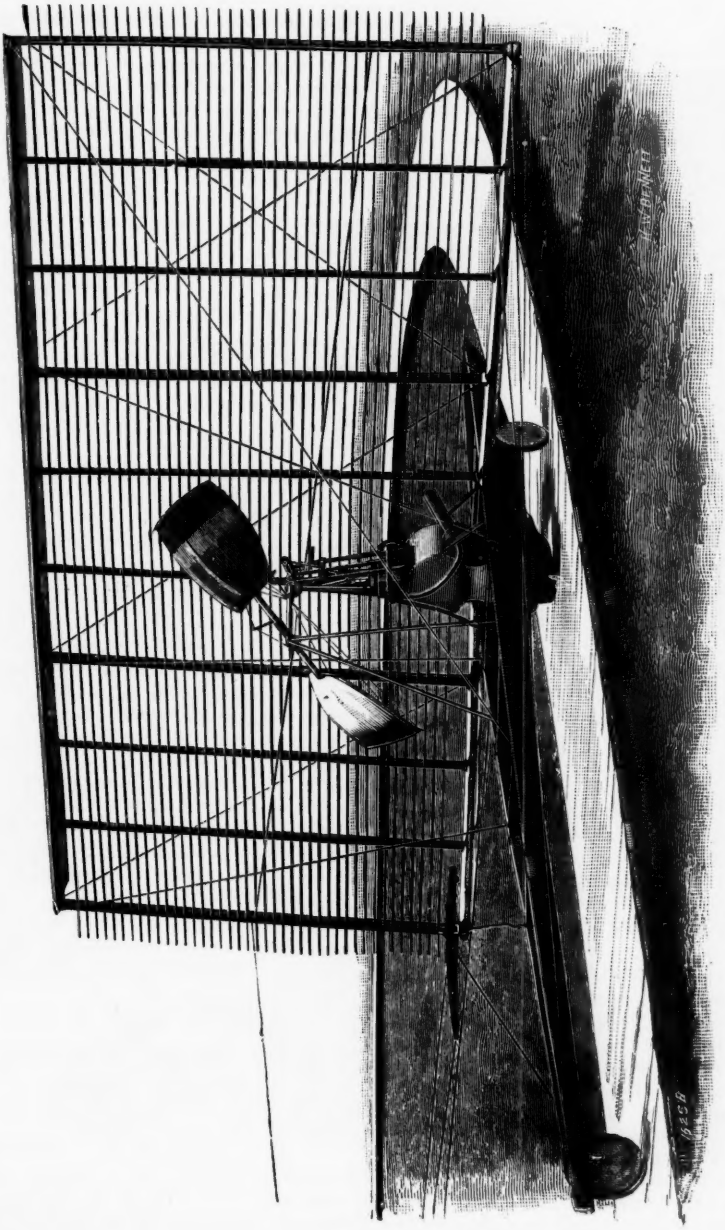


Fig. III.

to rise some 2 feet or 3 feet above the track, finally coming down again when the velocity fell off. The longitudinal equilibrium was found by trial, viz., shifting the weights until the front wheel barely touched the track. The best trial seems to have taken place on June 19th, 1893, when, with a speed of 40 miles an hour and load, 385 lbs., all the wheels were off the ground for about 2,000 feet of the distance traversed. The pitch of the propeller had been slightly reduced for this trial; it was noticed that when flying the slats appeared to be very nearly horizontal.

FULL-SIZED MACHINE.
Type 1904.

This machine is shown in Fig. IV It was very similar to the experimental machine of 1893, but was large enough to carry a passenger. The total weight was, with man, 600 lbs., and the machine lifted when a velocity of 50 ft. per sec. was attained; the brake H.P. was 22.

On trial, the longitudinal equilibrium was found to be defective; Mr. Phillips, therefore, prepared a new design.

FULL-SIZED MACHINE.
Type 1907.

This design is shown in Fig. V. It is similar to the 1904 type, but there are four sustainer frames instead of one.

The total weight is 500 lbs. (man 150 lbs. extra); the machine lifts at a velocity of about 30 miles per hour; brake H.P. of the motor varies from 20 to 22 H.P. at 1,200 revolutions. On trial the longitudinal stability was found to be very satisfactory.

The general dimensions can be judged from the propeller, which is 7 ft. in diameter.

REMARKS.

These experiments are very interesting. Like other aviators, Mr. Phillips has been much hampered by the want of a good experimental ground, but it is to be hoped that this difficulty will be overcome, and that he will be able to continue his meritorious work.

The President: We are very much obliged to these gentlemen for their papers. (Applause.) Is there any gentleman who wishes to say anything on the paper just read?

Mr. W. F. Reid: I think it must be agreed by all of us that, although this type of aëroplane may offer certain advantages with regard to stability, such a form must undoubtedly be extremely heavy as compared with other planes which are used in most machines. Whether it would not be better if the slats were made wider and there were fewer of them is a question. I am inclined to think it would be better. We should get the advantages of the Venetian blind system with, perhaps, a diminution of weight. It seems to me that is the one difficulty with this form of machine. Of course, what we particularly do want nowadays is actual experiments. We are much indebted to Mr. Phillips for the results of what he has actually tried. We are glad to hear that he has succeeded in rising from the ground with a machine which appears to me to be rather heavy.

Major Baden-Powell: Could Colonel Fullerton tell us how far the machine flew through the air. I understood him to say it did rise over the ground.

Colonel Fullerton: I do not know exactly, but I will ascertain.

NOTE BY MR. PHILLIPS.

The field I had for a trial ground was about 400 yards across. The machine was started close to the hedge, and rose from the ground when about 200 yards had been covered. When the machine touched the ground again, about which there could be no mistake, owing to the terrific jolting, it did not run many yards. When it came to rest I was about 10 yards from the boundary. Of course, I stopped the engine before I commenced to descend.

The President: We shall be pleased to hear any other gentleman. (No response.) We will go on with the next paper.

Stable Progression and the Wedge Shape.

By R. Balston, Esq.

On the last occasion on which I had the honour of reading a paper before this Society I took as my subject the shape of stability, of bodies falling through the air. I endeavoured to show that if you wish

Fig. IV.

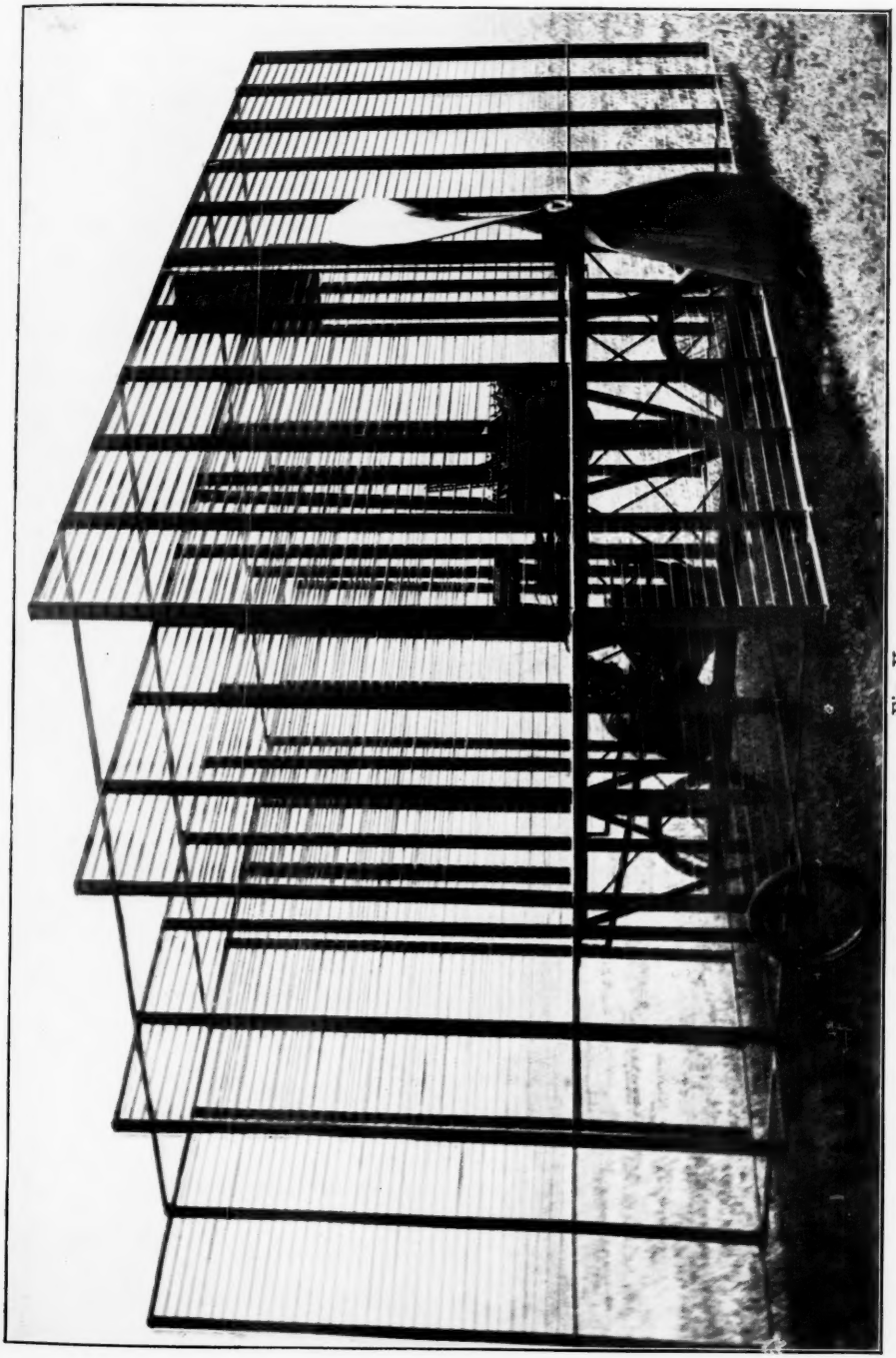


Fig. V.

to make an apparatus which will descend in perfect equilibrium you must do something more than give it lifting surfaces with the usual dihedral angle; that it is, in fact, necessary to extend this plan and form them with an upward angle in all directions from an approximately central point, thus making them take a form like the surface of an inverted cone.

To-night I want to ask you to look at stability from another point of view. A flying body, to be of practical value, must have, in addition to equilibrium of buoyancy, another equilibrium, viz., that of progression, *i.e.*, it must have a strong tendency to proceed with the same point of its framework always to the fore.

You will at once admit this necessity, I feel sure, for a moment's consideration of the subject will convince you that a machine which makes a practice of going on occasions broadside or stern first will never be satisfactory in the hands of anyone but an acrobat. Such a method of progression would closely resemble the behaviour of a heavy motor car on a greasy road, and no one who is familiar with the helpless feeling which a bad sideslip engenders will desire to repeat the experience in the air.

Inventors in the past have provided for this requirement which, for want of a better name, must be called stable progression, only in such a way as to produce very inadequate results; but there is a plan in existence whereby this equilibrium may be maintained economically as far as other factors of the problem of flight are concerned, which shows signs of coming into fashion, since it has appeared in one or two recent experiments.

Before explaining this new method let me first run over what has been done in this connection in the past. By this means you will be enabled to form a clear conception of the way in which the correct solution of the problem is being evolved. From the date of the first experiment down to some two or three years ago it is one long story of the development of the rudder or tail, *i.e.*, a tail of the type common to such birds as the blackbird, which trails this appendage, as it were, a long way behind its wings. It is a development which has been persevered in regardless of the fact that such birds are, without exception, flyers of a very second-rate order, and not to be compared to the swifts or to some of the gulls, whose tails are of so embryonic a nature that they can be of little or no account in flight.

In the earliest recorded experiments, of which the picture of M. Retif de la Brettonne is a good instance, the idea of stable progression never enters the minds of artists. No effort is made to keep the legs of the flying man behind him as he advances, and the only idea seems to have been to keep them below him, for, as you see in this particular instance, a basket is provided which was, no doubt, intended to be filled with stones.

Later on we come to the exploits of men like Oliver, of Malmesbury, who flourished in the 11th century. At first he placed very little importance upon the possession of a tail, as he attempted a flight from the top of a tower without one. At the same time the idea that something of the sort was necessary was beginning to dawn, for, on falling and injuring himself, he accounts for the accident by the fact that he had failed to attach a tail to his legs.

From that time forward no historical designer, whose drawings show a due consideration of the horizontal movement of his machine, ever fails to give the tail a prominent place, and though much else may be missing, in such sketches as, for instance, one of Leonardo da Vinci's drawn about the year 1500, the tail is always fully displayed.

Looking over the drawings of all early designers it becomes quite clear that they considered one particular form the right one in which to dispose their planes. They stretched out their wings in a straight line on either side and spread the tail behind, no doubt imagining that by this means they were copying Nature. In reality this plan is scarcely stable at all, and a close scrutiny of the position taken in actual flight by the wings and tail of a bird will reveal a fundamental difference from the imitations produced.

The most stable form for travelling forward is undoubtedly to be found in the dart which never attempts to proceed in any other position except point first. Butler and Edwardes, in 1867, no doubt perceived this when they patented an invention resembling one, and though this was doomed to failure owing to the inefficiency of such long planes when

driven lengthways through the air, which makes them unable to carry anything so heavy as a motor, nevertheless, it shows that attention had been given to the fact that flying machines are intended to move forward. It is, in fact, this form which gives us the key to the real shape adopted by Nature, and probably we cannot do better than copy it into our machines in the modified form to be found in birds.

The two shapes of efficiency are—for lifting purposes a long, narrow plane driven with its long edge first, and for purposes of progression a wedge-shaped plane like the dart. Nature manages to combine these so as to get the advantages of both. She makes her planes in flight take the form of a broad wedge. A paper model on these lines at once justifies itself by its appearance in flight.

Following the subject historically, when we come to the 19th century we still find the same disposal of the aëroplanes adhered to as had existed throughout. A picture of Henson's machine designed in 1842 shows this to advantage. The front planes are placed in one long line, and a capacious tail juts out far behind. Le Bris' machine of 1857 shows a similar arrangement, only carried out rather more artistically, and the tail is not quite so large. His machine of 1867 is just the same.

In 1871 a notable exception to the general view came out. This was an apparatus invented by M. Danjard. As he speaks of arranging the lifting surface so as to cleave the air he must receive credit for an attempt, at least, to produce the form required, though there is not much to be said for the way in which he carries out the idea. The idea of cleavage is not carried sufficiently far to take in the whole plan of the lifting surface. It stops half-way.

I must apologise to our German visitors for not producing a slide showing the wing plan of a machine invented by Herr Friedrich von Drieberg in 1843. I was not aware of his drawings until too late to obtain a slide, but you will find a picture in Major Moedbeck's Pocket Book of Aëronautics, page 282, which illustrates one of them. He has the best idea of the shape in question of anyone up to that time.

Apart from those inventors whom I have mentioned I can find no others who seem to have given the idea of "cleaving the air" a thought until our own day is reached, and even now the idea is not general, for we have lately seen a most successful effort carried through on the old system, for the machine with which Mr. Farman won the Deutch-Archdeacon prize has the square front adopted by all those who pin their faith to the box kite form of machine, and even in the new one which is reported to be building for him this square front, I am given to understand, is not departed from.

To turn to those recent experiments in which the wedge shape has appeared, M. Santos Dumont had, perhaps, something of this sort in view when he reversed the usual order of things and designed a machine with the tail in front. This is a more stable shape than the usual method, as I hope to show you with paper models, but I believe that the power required to drive a machine of this sort has turned out to be so large in practise that he has now discarded it. The reason of this fact is, I think, a simple one. When an aëroplane with a square front edge is driven forward, a layer of air is compressed in front of it, which has a thickness depending upon the inclination of the plane, and the particles in their endeavour to recoil strike directly back, their escape being limited to above and below the plane; but if the forward edge is disposed as a wedge the particles are driven outwards, so that many of them do not hit the aëroplane at all in their recoil, and those that do have lost much of their retarding effect because their return is at an angle to the course of the plane.

Mr. Clark owes something of his success in producing the latest mechanical flyer to the fact that he has placed his largest pair of wings behind instead of in the front of his apparatus, but I should be interested to see the effect of setting the wings back at their tips, as I feel sure that the improvement in their flight would be marked.

Mr. Weiss, in his experiments with gliders, has really made the greatest strides in producing a shape which cleaves the air, and there is only one particular in which his models come short of the perfect shape as far as I am aware. It is that he does not go far

enough in drawing back the front line of his aëroplanes, *i.e.*, from the point of the wedge to the base. This is probably owing to the fact that he keeps his wings broad at the tips, which tends to prevent successful results with an acute angled wedge. Perhaps he has good grounds for adopting broad tips to his wings, but if not, I think that the shape is a mistake, as it is not to be met with in Nature.

Perhaps I ought to bring mathematical calculations to bear out my argument, but I am unable to do so for the reason that my subject is new and as yet untouched, as far as I am aware, by mathematicians. This is not altogether a matter of importance, for my object is not so much to convince, as to bring the subject before you in hopes that it may receive mathematical treatment from those who are able to deal with it as I feel sure it deserves, and in order to dispose of the principal difficulty which experimentalists will meet with, viz., an easy means of obtaining data, I have brought with me the design of glider already shown which, I think, many of you will find useful in this and other ways. It is made in a very simple way. You merely fold a sheet of paper in halves and upon one side you draw half the wing plan of any machine which you desire to test. Having cut out the plan with a pair of scissors you spread out the paper as nearly as possible in its original form, after which you must bend it at right angles to the former fold to give it falling stability. Add some sealing-wax as ballast to provide it with gliding power, and a trial will at once give results which will be approximately true for machines of any size. I have with me models of various machines made on this plan, and I will bring my paper to a close by showing you their behaviour in the air.

Some interesting lantern slides were shown on the screen, and the flights of Mr. Balston's paper models of birds, etc., were greeted with much appaluse.

The PRESIDENT: We are much indebted to Mr. Balston for his interesting examples of flight and for his paper. I am sure it invites a lengthy discussion, and we unfortunately have not very much time for discussion. We hope that if there are any foreign gentlemen here, that they will help us with the discussion. (No response.) I will call upon the author of the next paper to read his paper.

The Efficiency of Aëroplanes, etc.

By W. R. TURNBULL, M.E.

When we examine the numerous designs that have been proposed for power-driven aëroplanes it is most apparent that the designer, in most cases, has lost sight of the all-important subject of the efficiency of the different parts.

The aëroplanes are often quite large enough to give the required "lift," but the "drift" is enormous, the propellers are usually far too small in diameter, and the motor is so poorly cooled and adjusted, that it is not capable of giving anything like its rated power.

Any one of these faults is sufficient to make a failure of a possible success, but when they are combined, as they usually are, the machine is hopeless. I have just seen in Paris a machine glaringly wrong even in the most elemental principles, yet the builder had spent a large sum of money for a costly motor and its accessories.

The machines of Farman and the Wright Brothers have been designed with a good knowledge of the mechanical principles involved, and the workmanship of the Voisin Brothers is exquisite, but these machines are at best very crude; the stability in anything but calms and light winds is doubtful, and the propeller has been greatly compromised to suit the rest of the design.

In the most successful machine that has publicly flown we have 38 brake horse-power expended to carry a man at 30 miles an hour, and we have the assurance of the Wright Brothers that the necessary power increases at a much higher rate than the speed—"Langley's law" notwithstanding.

Personally I do not consider the soaring machine with air-screws and motor attached gives a practical solution of our ancient problem, but if this machine is really the prototype of the machine of the future, that will navigate the air regardless of wind and weather, its only

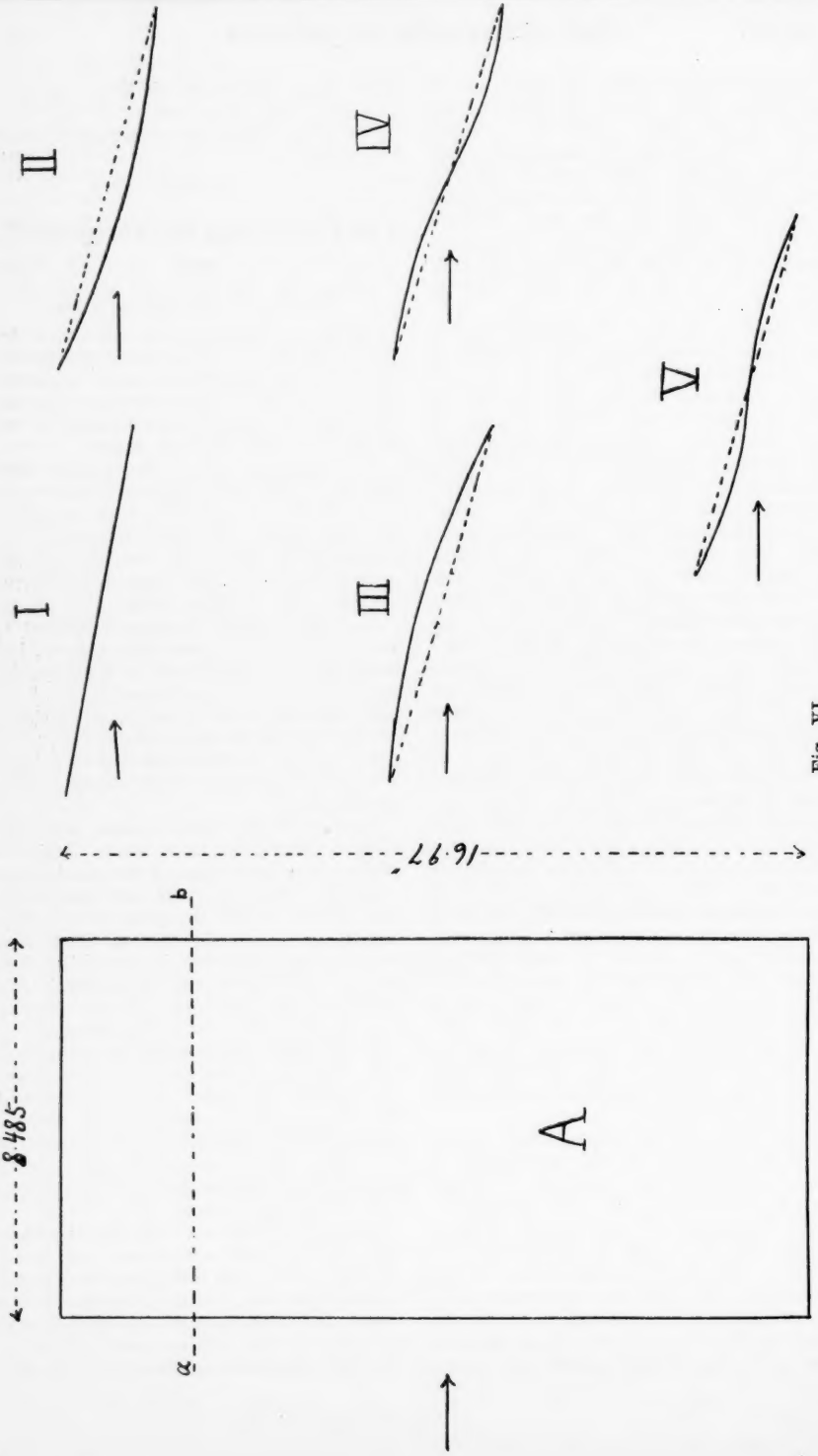


Fig. VI.

hope is in maximum efficiency at every point.

When one tries to design an aërodyne of practical form one must make compromises at every point; the shape of the aëroplanes is compromised by mechanical considerations, the propellers always have to be reduced in diameter and increased in speed to conform with the rest of the design, and the motors are improperly cooled to "save weight."

All these compromises mean losses in efficiency, and the unfortunate part of the problem is this, that loss in one part of the machine means loss in another part. For instance, if our planes are inefficient, our propellers have to do unnecessary work, and if the propellers, too, are inefficient, a much larger engine is required to drive them; all this means, in turn, larger aëroplanes than would be otherwise needed, and so on at "compound interest," so to speak.

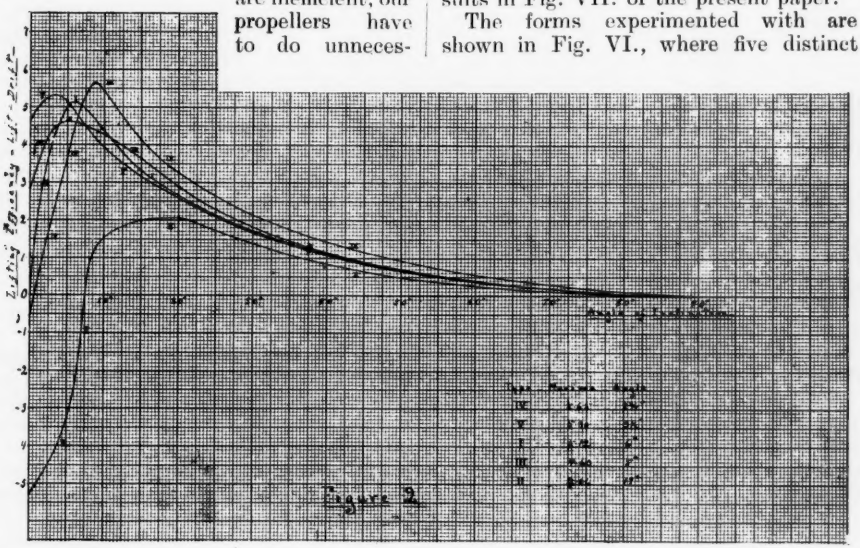


Fig. VII.

THE EFFICIENCY OF AEROPLANES.

The most efficient form of aëroplanes is probably not known, with certainty, at the present time, but it is likely that a thin "plane" of double curvature, concave underneath at the forward portion and convex underneath in the rear portion, is a close approximation of the best form.

Its curvature follows the so-called "stream-line" of fluids, but it is quite possible that some thickening of the forward portion, as we find it in the wing of a bird, is necessary for maximum efficiency.

In the bird, however, this thickening *may* only be demanded for mechanical strength, convenience in folding, etc.

In March, 1907, I published in the "Physical Review" a paper on the lifting power and stability of aëroplanes, and I have since worked out the efficiency of the various forms and present the results in Fig. VII. of the present paper.

The forms experimented with are shown in Fig. VI., where five distinct types are shown as follows:

Type I.—The plane surface.

Type II.—The single curvature surface, convex on the under side.

Type III.—The single curvature surface, concave on the under side.

Type IV.—The double curvature surface, concave at the forward portion, convex at the after portion, on the under side.

Type V.—The double curvature surface, convex at the forward portion, concave at the after portion, on the under side.

In order to simplify the problem and to make the results, with the five differ-

ent types, strictly comparable with one another, I dealt only with surfaces having a rectangular plan view, and in which the width (at right angles to the air-current) was twice the length (in the direction of the air-current). While this method fails to cover the whole ground, since the number of possible plan views is practically limitless, I feel assured that, so far as general laws are concerned, the two-to-one rectangle is fairly typical of all forms.

A, Fig. VI., shows the common (developed) plan view and the various sections along any fore-and-aft line *ab* are shown from I. to V., the arrow in each case showing the direction of the air-current.

The forms experimented with were made of tin held in shape by three longitudinal ribs at the back; their lift and drift was measured in a uniform air-current of 10 miles an hour at angles from zero to 20°.

By dividing the lift in lbs. by the drift in lbs. of each of these forms, at corresponding angles, we obtain a measure of the efficiency of the different forms, as lifting agents. Knowing that the efficiency of all the forms *approximates* zero at 90° we can produce the curves to zero at 90°, although we are really concerned, in flight, with angles between zero and 20° only.

The curves so obtained are plotted in Fig. VII., in which ordinates represent efficiencies and abscissæ give the corresponding angles of inclination of the aëroplane to the air-current.

With the single exception of Type II. the efficiency of all these types is very good, but it is particularly good at small angles for Type V., and particularly good for Type IV. at angles from 7° upwards.

Type III., the form of maximum lift, *per se*, is not the most efficient form, for at small angles V. is better, and at larger angles IV. is much superior.

All the types reach maximum efficiencies at angles varying with their forms as expressed in the following table:

TABLE I.

Type.	Max. Efficiency.	@ Angle.
IV.	5·65 ..	@ 8½°
V.	5·30 ..	@ 3½°
I.	5·12 ..	@ 6°
III.	4·60 ..	@ 5°
II.	2·06 ..	@ 19°

From this table we note that Type IV. gives the highest efficiency, and Type II. the lowest; and these are the only types, of the five, having automatic stability (as pointed out in my previous paper), so that all the advantages seem to point to Type IV. as the best form that can be used.

Moreover, a more efficient form still of Type IV. consists in making the forward two-thirds of this aëroplane concave underneath, and making only the rear third convex; whereas Type IV., shown in Figs. VI. and VII., has the concave and convex portions equal.

Farman, in his successful machine, used this latter form of Type IV. for his forward aëroplanes, but undoubtedly the rear cell of his machine reduced the efficiency, as a whole, and the aëroplanes of his machine are the most efficient part of it.

My deductions, from Fig. VII., may not be correct for all speeds and all plan views, but my experiments would indicate that with greater ratios of width to length the superior efficiency of Type IV. would be even more pronounced than in the "planes" with a ratio of 2 to 1.

THE EFFICIENCY OF AIR PROPELLERS.

The subject of air propellers is a most difficult one to deal with, as the data is very meagre, and we sorely need, at the present time, a very complete research on the subject.

Just as soon as we know the best type, and the best proportions and speed, for every diameter of screw, we can properly classify air propellers and obtain definite ideas as to their performance; in the meantime we must be content with makeshift methods.

So far as possible I have obtained the data of a large number of air propellers, both good and bad, I fear, and have compared them in Figs. VIII. and IX. as best I could.

Fig. VIII. gives the results for twenty-four propellers compared as to their tip speed and estimated brake horse-power, the estimate of brake horse-power being obtained by reducing the given indicated horse-power by 20 per cent. in accordance with the average results obtained in practice.

While the points in this figure are very

scattered, a mean curve, for modern practice, may be drawn as shown; it passes through a point at 40-H.P. and 31,000 feet per minute, tip speed, where five modern propellers give practically the same result, and this curve may be considered that of the present-day propeller with two narrow concave blades, driven at much too high a speed for good efficiency.

This curve gives no clue to the efficiency of air propellers, but it may be useful to those designing a typical modern propeller, for, with the speed and horse-power known, the diameter is at once determined by a simple calculation.

The wide scattering of the points in this figure is due to the various forms and efficiencies of the different propellers, and emphasises the importance of careful research to obtain the best form.

Fig. IX. gives a better idea of the efficiencies that have been obtained in the past, although it has been difficult to get accurate data for the thrusts. Altogether only eight propellers are represented.

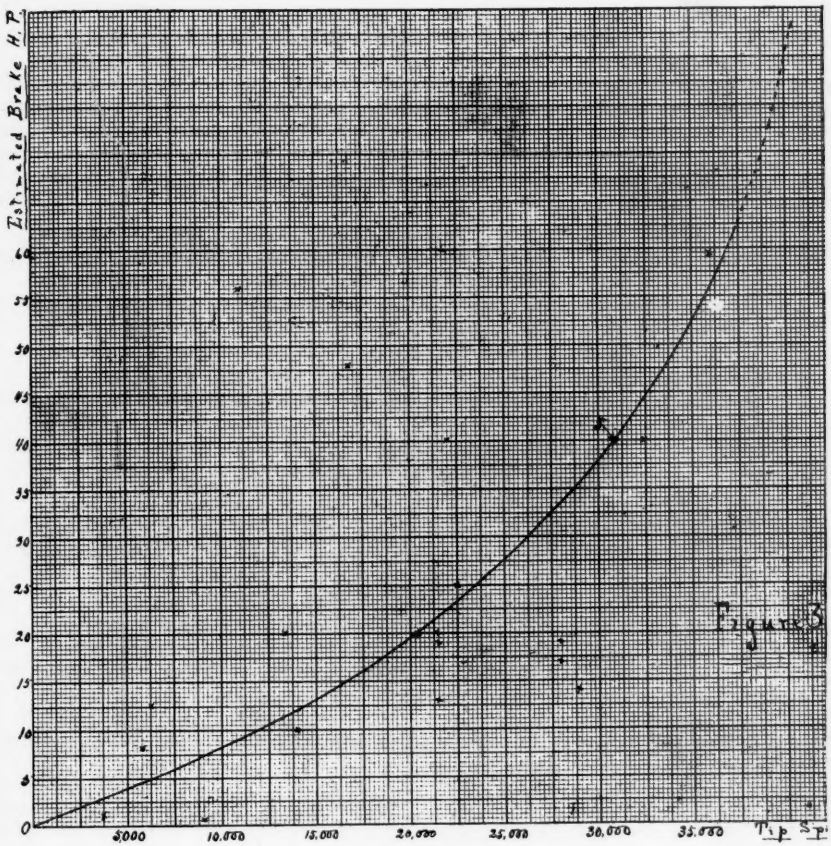


Fig. VIII.

As in the previous figure, abscissæ are tip speeds in feet per minute, but the ordinates represent the thrust in pounds per brake horse-power, thus giving a measure of the efficiency at varying speeds.

Points A and B are the figures of

Renard, published in 1889, for the same propeller, of 23 feet diameter, at two different speeds. Point C is the result of Brequet (1907) for a helicopter screw of 26.5 feet diameter. All the other points are for modern high speed screws of about five to seven feet in diameter.

The falling off in efficiency at the higher speeds is most remarkable, for while it seems possible with the most efficient screws to get thrusts of 40 or 50 lbs. to the horse-power, the modern aërodyne has a screw of one-sixth this efficiency, or about seven lbs. per horse-power.

This particular compromise of using a small high speed screw to suit the rest of the design has cost the modern aërodyne an enormous toll, and it is right at this point that the present design is decidedly poor, for it means we have to carry an engine six times heavier than it should be, and that means much larger aëroplanes (with their additional weight) to carry the extra weight of the motor.

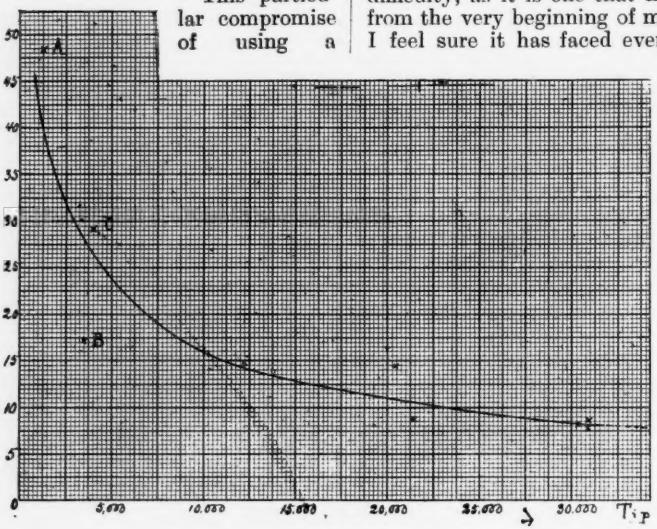


Fig. IX.

The efficient air screw is one of large diameter turning at a comparatively slow speed, and such a propeller is absolutely incompatible with the power-driven soaring machine, as we have it developed to-day by the Wright Brothers, Farman, and others.

These machines have succeeded in making short flights by the application of marvellously light, powerful motors, but they are machines of *great* inefficiency, and of uncertain stability as well.

Sooner or later we will be forced to study this subject of efficiency if we are to arrive at a practical solution of aërial navigation, and the present indications are that the air screw is not the ideal means of propulsion, at least, for aërodynes of the present type.

I cannot say what the ideal means of propulsion is for a soaring machine, for I do not know, but I am constantly shaping my experiments to overcome this difficulty, as it is one that has faced me from the very beginning of my work, and I feel sure it has faced every man who has taken up the subject seriously from an engineering standpoint.

The efficiency of air propellers, as is well known, is increased by a cross current of air, but this is necessarily of a variable and often vanishing amount, as a man cannot always sail "with a beam wind."

THE EFFICIENCY OF THE MOTOR.

The efficiency of the present-day gasoline aëronautic motor is impossible to determine, as it is a very variable quantity, much to the discomfiture of the experimenter.

By the efficiency I do not mean the thermodynamic or mechanical efficiency,

but simply the weight of the motor and its accessories per brake horse-power.

Extravagant claims are, unfortunately, made by nearly all the manufacturers for motors weighing from 3 to 4 lbs. per H.P. down to 1.6 lb. per H.P., but these claims are not fulfilled. With practically all the aëronautic motors the cooling of the cylinders is not good, and after about 10 minutes' running the horse-power falls off to an alarming extent. If a motor weighing with its accessories 4 lbs. per H.P. delivers only one-half its power after a 10-minute run, it is an 8-lb. motor and not a 4-lb. one, and we have at this point a falling off in efficiency of 100 per cent.

Summing up the conclusions I have come to, the double curvature aëroplane of Type IV. is fairly efficient, giving a lift five-and-a-half times greater than its drift at its best angle; the gasoline motor has wonderful possibilities, and the present difficulties are bound to be overcome in time; but the *bête noir* of the whole problem lies in the unsuitability of the air screw as a means of propulsion, owing to the inability to properly incorporate it in a correct mechanical design, without impossible distortion and absurd mechanical construction.

I am sorry to be pessimistic about the screw-driven soaring machine as we have it to-day, for at one time I had great faith in it, but the more I have worked on the problem the more firmly I am convinced that it is not the prototype of that successful machine which some day will unquestionably solve the great problem.

NOTE.—After my paper a gentleman in the audience made some remarks, the purport of which were that because the Farman machine flew at a high speed the r.p.m. of the propeller had to be high. He overlooked the questions of *pitch* and *diameter*, however.

The figures given for the Farman machine show the relation of $\frac{\text{pitch}}{\text{diam.}} = 0.609$, *the slip equals 45.2 per cent.*, and the pitch angle at tips about 11 degrees, r.p.m. = 1050.

Now, an efficient propeller for the Farman aëroplane, *giving the same speed of machine of 30 miles per hour*, works out about as follows:

$\frac{\text{pitch}}{\text{diam.}} = 1.2$; slip = 15 per cent.; pitch angle 21 degrees.

With a diameter of 15 feet (*ignoring the rest of the design*) the pitch is 18.1 feet and the r.p.m. = 172, or about *one-sixth* of that used.

The PRESIDENT: We hope that some gentleman will lead off the discussion on this paper for a short time.

A MEMBER: I think that, in my opinion, the air propeller of the helicoptere type got its enormous thrust because it turned round in this position (demonstrating) and had a packed earth below it. If you were to take it and turn it around in the air, blowing in free air, it would not get the thrust. That is my opinion from running a screw propeller up against a wall, and it would give 20 per cent. greater thrust than it would if the wall was removed and the earth got away from it. Although it made a bigger load for the engine, that, I think, is the cause of the helicoptere type in a large scale giving a greater lift than the modern little one.

A MEMBER: Did not Colonel Fullerton say that Mr. Phillips had a drift 20 to 1? I understood the speaker to say the ratio of lift to drift was 5.6 to 1. I think in Mr. Phillips' paper he said it was 20 to 1.

Colonel FULLERTON: Are you alluding to Mr. Phillips' paper?

MEMBER: Yes.

Colonel FULLERTON: With type shown in Fig. 2 on the blackboard the lift was 20 times the drift.

MEMBER: And in this paper the best result was 5.6 to 1.

Mr. TURNBULL: I might say in reference to that, that Mr. Phillips has always claimed very much greater efficiency than any other experimenter. I have not a doubt but what his figures are right, because he uses an aëroplane of very peculiar form. The length in his case is, perhaps, 40 or 50 times the width of the aëroplanes. In the experiments that I made the length was in the ratio of 2 to 1. In Mr. Phillips' case it is probably in the ratio of 30 or 40 to 1, and, of course, that makes a great difference. With my figures they are simply comparative.

Mr. COWPER: May I ask the author how he obtained the figures that he mentioned and put on those diagrams? Were experiments made after Langley's method? And may I ask also whether he attained greater accuracy than Lang-

ley? I think everyone knows that the Langley results are contradicted at a certain inclination by Dine's results, and there is a considerable doubt attached to them. I should like to know what form of machine—if he found them for himself—he used. I am sure everybody is deeply grateful to the author for the paper, and that he has made and brought forward a very good attempt at a scientific theory of efficiency, in which he has given the curves relating to the various different forms. The question of efficiency has been very little considered, I think, by designers of practical machines, and we must be very grateful to the author for having brought it forward. There is a point with regard to screw propellers also, which many people neglect, *i.e.*, the difference between the conditions when the propeller is merely creating a draught and when it is moving through air and acting on stationary air, air that has not been disturbed. It is obvious that the conditions are absolutely different, and that the design of a propeller that will give the biggest thrust when stationary is not necessarily that one which will give the best thrust in a moving machine.

The PRESIDENT: We shall be delighted, above measure, to hear Sir Hiram Maxim. (Applause.)

Sir HIRAM MAXIM: Mr. Chairman, Ladies and Gentlemen, on account of my deafness it was quite impossible for me to understand what was said here to-night, though I caught a few words in regard to the screw thrust and the efficiency of screws. I must say that the efficiency depends in a large measure upon the degree of accuracy with which the screw is made. In my large experiments, where I had, we will say, 150 to 160 horse-power on each particular screw—the screws being 18 feet in diameter—I found when the machine was tied up and the engines were running full speed that the two screws gave a thrust of nearly 2,200 lbs. on a dynamometer that I had provided for the purpose. At that thrust, if we multiply the pitch of the screws by the number of turns they were making in a minute, we shall find that the slip of the screws was 60 miles; consequently, with 60 miles slip in the air, they gave a thrust of nearly 1,100 lbs. each screw. When the machine was running through the air at the rate of 40 miles an hour, of course, the slip was reduced to 20 miles an hour, and, according to the way some people look at it, the thrust ought to have fallen off, as the square of 20 is less than the square of 60; but it did not do so. It was constant, no matter what the speed was. Whatever the slip was, whether it was 20 running, or 60 standing still, the thrust was constant, and that was because the screw was constantly running into new air, the inertia of which had not been disturbed. When the screws were running and the machine tied up, the screws very soon established a current of air, and the whole engine-power was devoted to maintaining that current of air. I had a small apparatus for testing small screws; the shaft could play lengthwise, and I had an accurate dynamometer to register the thrust. I put a screw on and started the apparatus. The thrust went up to, say, 20 lbs—that is, the end thrust on the screw shaft was 20 lbs.—and then dropped back to 14 lbs. It occurred to me that this might be due to the momentum of the moving parts. I checked it at 14 lbs., but it went to 20 lbs. and came back to 14 lbs. just the same. This shows that the thrust when the air had not been disturbed was much greater than it was when it had once established a current. Suppose my screws were running at full power, and that there was a sudden gust of wind; the thrust would momentarily run up very high indeed. I made a screw with the framework covered with cloth; the efficiency was much less than with a well-made wooden screw. For instance, in my very accurate apparatus for testing screws 18 inches in diameter instead of 18 feet, I found that with a very carefully-made dynamometer, if I multiplied the thrust of the screw in pounds, by the number of turns in a minute and by the pitch of the screw in feet, it corresponded exactly to the readings of the dynamometer, providing I had a well-made wooden screw, that is, a perfectly accurate screw. With any form of built-up screw, such as a sheet metal screw, or one made of woven fabric, it would be much less. For instance, the best fabric-covered screw was only 40 per cent. as efficient as a well-made wooden screw. I found with a well-made wooden

aëroplane set at an angle of 1 in 18 above the horizontal, that the lift would be 18 times greater than the drift; therefore, I think, a great deal depends upon the accuracy with which the work is done. The Wright Brothers have found that it is best to use a wooden screw. (Applause.)

Mr. TURNBULL: As to Sir Hiram Maxim's remarks, I might say that I visited Professor Graham Bell's laboratory last autumn, and he had a rather clever way of making a wooden screw. He simply took a number of strips of wood, laid them on one another, and fixed them like the sections of a lady's fan, and in that way. Then all that there was to do in order to finish the propeller was to smooth over the surface and thus the true screw shape was obtained. He claimed to have the true screw shape in that way, and it is a propeller that is very easily made, and when it is made of pine wood it is very light indeed.

Sir HIRAM MAXIM: I would say that the process of making screws described by the gentleman is the one employed by myself, and is a very common process. In some countries, when they have a screw propeller to make, they cast it from a wooden pattern, which is always made in that way. It is the draughtsman's business to lay out the screw in such a way that when these fan-like pieces are spread out they are exactly the right width between the corners for the thickness of the blade. There is a regular system of laying out screws, and when the pattern maker has glued the pieces together, he works them down just sufficiently to take out the corners. It is a simple matter. My screws were 18 feet in diameter and made of American white pine.

The PRESIDENT: Has any other gentleman anything to say? I thank the author for the paper and those who have helped in the discussion. I do not know whether Mr. Turnbull would like to say anything further in reply to the discussion on his interesting paper.

Mr. TURNBULL: No, sir. I might just mention that I brought some of my former papers with me. There are about twenty copies on that table, and it would, perhaps, lead some of the members to follow the present paper if they take those copies as they leave, and I will be very pleased to send copies to any who are not supplied. (Applause.)

The PRESIDENT: I will call on Mr. Clarke to read his paper.

A Model Aeroplane.

By T. W. K. CLARKE, ESQ., B.A.

(See Fig. XXI.)

The particular design of flying machine about to be described was the outcome of attempts by the writer to obtain an aëroplane model of high efficiency and of very strong construction. In view of the enormous number of cases in which experimenters have spent months, sometimes years, of hard labour evolving a machine, a veritable marvel of model construction, only to see it at the first trial dashed to pieces, or, at the best, damaged to such an extent that the time taken to put the model into working order again is entirely out of all proportion to the useful information gained, the writer recognised that, in order that

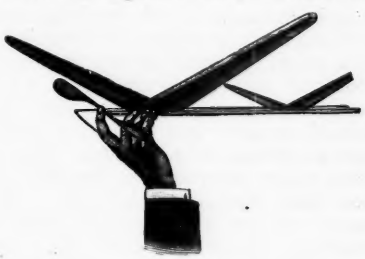


Fig. XXI.

any machine shall pass through the ordeal of the preliminary trials for getting the best positions for the surfaces, weights, etc., and shall be capable of being used for a consecutive series of experiments, it must be practically unbreakable, and the various parts must be simple and renewable. Lightness was considered of secondary importance, extra weight being only a matter of higher speed, while at the same time it ensures greater stability.

The question arose as to the type of machine to adopt. The general opinion seems to be held that a double-deck machine is steadier than a single-decker, but the writer found that there was no great difficulty in making the single-

decker quite stable, so long as the surfaces, etc., are made sufficiently rigid; this latter requisite is, of course, more easily accomplished with a double (or multiple) decker, as the depth between the surfaces allows of the whole structure being stayed to form a complete girder. With the multiple-decker there is also the disadvantage that when the lower surface strikes the ground, the inertia of the upper surface puts tremendous strains upon the fore and aft bracing, and also the struts.

As to efficiency, the experiments of Langley and others show that the efficiency of superposed surfaces is not so good as that of single surfaces, although when separated by a distance greater than their width, the loss is small, yet when this distance is reduced, the loss becomes very appreciable; as an example, Mons. Santos Dumont's first double-decker showed a very low "speed-lift" efficiency. For these reasons the superposed system was discarded, and surfaces in tandem were adopted. The writer is not aware of any experimental work in connection with the interference of surfaces in tandem; his experiments with small gliders, formed by clipping two small paste-board surfaces to a backbone formed of a flat wooden lath, seemed to show that when the surfaces were separated by a distance less than three times the width of the front surface there were distinct signs of interference, causing unsteady and erratic behaviour, and, in any case, the farther apart the surfaces were placed the steadier was the flight. For preliminary experimental work the writer found Venetian blind laths very useful, as they are all of even thickness, $\frac{1}{8}$", made from clean yellow pine, and can be easily split with a cutting gauge to any width.

Quite good gliders can be made by clipping two such laths (slightly hollowed) crossways on to a third piece and weighting with a piece of metal. The writer has caused such a glider to float on a strong upward wind for just over 20 seconds.

For the propelled models a tough lenticular-shaped frame was found to be just the thing, and to this the surfaces were clipped by loops of elastic, being thus held in place by friction. This principle of a springy frictional grip was applied also to the propeller and serves three useful purposes:

(1) The surfaces or propeller slip or yield when any part of the machine strikes the ground heavily, otherwise the inertia of the surfaces would cause them to break away from any fixings.

(2) The surfaces can be adjusted in any direction.

(3) The surfaces or propeller can be changed.

To accord with the results determined by Lilienthal, Professor Langley, Mr. Phillips, and others, the surfaces were made as narrow as possible in the direction of their length and very wide, the ratio of width to length being, in some cases, as much as 20 to 1. The section was similar to those used by Mr. Phillips, and the under sides were hollowed, the maximum thickness being at $\frac{1}{3}$ or $\frac{1}{4}$ of the distance from the front edge. The back edge was fined off, the front being left blunt.

The surfaces were fined off to a point as far as practicable at their extremities, not only for considerations of strength, but chiefly so as not to have an abrupt discontinuity of surface, such as we have in the case of surfaces which carry their full width right out to their extremities, which are square, and the writer thinks that, if only we could see the turmoil in the air which must be caused by such square ends, we should be inclined to go to a little more trouble and, in shipbuilding language, make the lines fair.

Experiments were made with three or more surfaces in tandem, but it was found that two only gave the best results, and the best results were those in which the front surface was considerably smaller, *i.e.*, about $\frac{1}{3}$ or $\frac{1}{4}$ of the back or main surface, and inclined up at a positive angle to it of a few degrees.

These results were to be expected as the front surface must form a wake in which the rear surface travels, hence the necessity of making the front surface small, contrary to the custom of most experimenters, which is, with single-deck machines, to place a small surface behind, where it is continuously in the wake of the main surface; probably with the idea of copying the bird, but in this respect it may be noted that Mr. Weiss and others have shown that a bird's tail is by no means a necessity for its flight.

As to longitudinal stability, it has often been said that the great desideratum in an aëroplane machine is to so design it that the centre of pressure on the surfaces shall be fixed in a certain position, namely, so as to coincide with the centre of gravity of the machine and to remain there for varying angles of flight, but this is just what must not happen, the essential condition of automatic equilibrium is that as a machine begins to dive downwards, the centre of pressure shall move forward, ahead of the centre of gravity, and so produce a moment of recovery, which will bring it back to its proper slope.

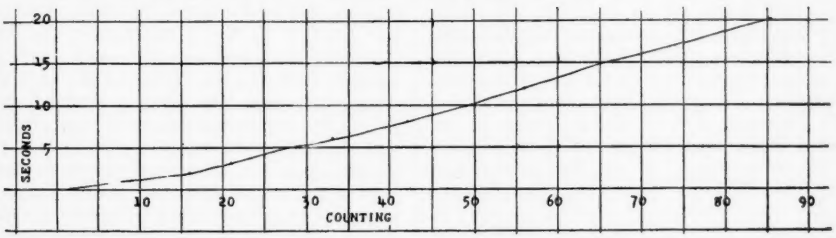
In the case of a machine with plane surfaces this (we know from experiments on plane surfaces) is what actually does happen; as the machine plunges, its speed forward increases, and the air impinges against the surface or surfaces at a finer angle, the resultant pressure moves forward and tilts the machine up and back to its proper position.

But when we come to curved surfaces it is not so simple, the centre of pressure does not necessarily move forward as the angle of incidence decreases, and the consequence is, that the surface by itself will probably be unstable; this is easily shown with a piece of card.

It follows that there must be some small downward curvature which is just neutral.

This innate instability of a simple curved surface can be counteracted in a complete machine by adding a small reverse curvature at the back of the surface; this is the method adopted by Mr. Weiss in his machines; or we may have, as adopted by the writer, two or more surfaces, the front one being set at a small positive angle, say, α to the back. Under these circumstances, when the back or main surface is inclined, say, β to the direction of motion, the front surface is inclined $(\alpha + \beta)$, and when α and β are quite small the pressures on the surfaces are proportional to these angles, and the ratio of the pressure on the front surface to that on the back is $\frac{\alpha+\beta}{\beta}=1+\frac{\alpha}{\beta}$ a ratio which increases very fast as β is reduced, so that when the machine begins to dip and the velocity is increased, β is thereby decreased and the pressure on the front surface increases rapidly, a righting moment is set up and equilibrium is restored; it is just the same action only somewhat more complex, as that which causes a dihedral angle given to the surfaces to preserve transverse equilibrium, and which is expressed by the statement that a necessary condition for stability is that the surfaces, taken as a whole, shall have a general convexity downwards.

DIAGRAM to show Time in Seconds corresponding to fast mental counting.



In this connection it may be noted that, as in ship design, we can very conveniently study the stability and rolling actions by means of a quantity called the metacentric height, and certain curves connected with it, which are calculated from the designs, so, in the case of aëroplanes, there are corresponding quantities and curves which will be of great use in estimating the stability and behaviour of large machines; the calculation of these quantities will be a problem considerably more complex than in the case of ships, but, in certain cases, *e.g.*, in the case of machines similar to the model described and having surfaces with curvatures giving neutral stability, the problem will admit of comparatively easy solution.

To get back to our subject. In order to carry out a consecutive series of experiments the writer had prepared a set

of frames with blocks of various slopes attached for giving various tilts to the surfaces relative to the direction of thrust and to each other; sets of surfaces of different shapes, areas, weight and curvature; propellers of varying area and pitch; and skeins of elastic of varying amount. Each of the above was lettered and classified. Thus it was possible to vary different elements of the machine independently and so to try to obtain the best combination.

These results are given on the accompanying sheets.

Preliminary experiments with the propellers were carried out by suspending a frame with elastic and propeller (horizontally) by four parallel vertical threads and measuring the thrust by means of a spring balance attached to the frame. Various kinds of propellers were first tried, paper on wire frames, magralium sheet on wood, all magralium, but these wooden ones were found to be much the strongest and most satisfactory when the blades were well balanced and in an easy bearing. The thrust was generally about 85 per cent. of that which can be calculated from the Torque, and which, on the accompanying sheets, has been called the Thl. Thrust. This calculation follows from the ordinary statical laws of moments, or, better still, by application of the principle of virtual work in dynamics, for we get Thrust × pitch = Torque $\times 2\pi$ or Thrust = $\frac{2\pi}{\text{pitch}}$ × Torque, this being true at all speeds so long as the friction and edge resistance are neglected.

In the case of hollow-spooned propellers the chord was taken for measuring the pitch.

From the above we see that with a given Torque the thrust depends only on the pitch, not on the area of the blades, the latter being determined by the speed at which it will have to run, hence the process of designing a propeller was:

(1) To weigh the machine, say, 1½ lbs.

(2) See at what angle it will glide, generally about 1 in 5½ or 6, say 1 in 6 then required Thrust = 1/6 = ¼ lb. = 4 oz.

(3) Find the maximum amount of elastic that can be used without unduly upsetting the balance of the machine and the corresponding Torque due to it, say 36 oz.-inches. Now it will be found that the average thrust is somewhat greater than ½ the maximum thrust, for the extension of elastic is not exactly proportional to the tension, the ratio decreasing as the tension increases. Hence the average Torque would in this case be about 20 oz.-inches—the required pitch = $\frac{2\pi}{\text{Thrust}}$ × Torque.

$$= \frac{2\pi}{4} \times 20$$
$$= 31\tfrac{1}{2}'' \text{ approx.}$$
say, 32″.

The above were taken from an actual model, and experiment showed that this gave the right pitch.

(4) There still remains the area and diameter to determine. These were determined in the workshop, for experiment showed that the speed of the propeller was but slightly less when the machine was at rest than when in motion, hence the area must be such as to allow the propeller to revolve at a speed corresponding to the proper forward speed of the machine after allowing for slip, or in the present instance the machine weighed 1½ lbs. and had 1½ square feet of area given a load of 1 lb. per square foot, and its proper speed was found by experiment to be about 40 feet per sec. (37 feet per sec. was to be expected from the published results of various full-sized machines). Now without slip the propeller should go forward 32″ per revolution; if we allow 30 per cent. slip, it would progress 22″ per revolution, and 37′ divided by 22″ gives 20 as the number of revolutions per sec. for the propeller. This was slightly in excess of what gave the best results.

As to the shape, the section used was similar to that of the surfaces, viz., slightly hollow, fine on the back edge and blunter on the front edge, the contour was sometimes long and narrow, and sometimes spoon-shaped. When the blade portion of the latter was kept at a constant inclination rather than at a constant pitch there seemed to be rather greater efficiency, that is to say, a pitch increasing outwards slightly seemed to be a benefit, in such cases the pitch tabulated is that taken about two-thirds of the way outwards along the blades portion. Some of the earliest surfaces tried were only about 2¼″ wide, had a considerable dihedral angle, were shaped ∼ and were somewhat heavy; these were very erratic in their behaviour, generally failing by a sudden rotation

sideways, causing them to fall to the ground almost at starting; from subsequent experience the writer is inclined to think that, owing to the narrow bearing length on the frame, the spring clips were not strong enough to prevent the bending backwards caused by their inertia when being thrown off, another cause was the difficulty of making the inclination of the curved extremities of the wings the same as that of the central portion. When a surface wider in the centre and tapering finer towards the tips, of simple V shape with a much flatter dihedral angle was tried, the improvement was at once very marked.

As to the hollowness of the surfaces, it was found that if they were flat underneath, a much greater thrust was required and the machines were erratic; this is common experience with experimenters, but when a hollow is given they at once appear to float easier, as though on ball bearings.

But in the case of the heavier models the best results were given by a curvature less than what had been expected. In the case of a load of about 1 lb. to the square foot, the best curvature was 1-24th of the width, and with models $\frac{1}{6}$ lb. to the foot it appeared to be 1-12th of the width. A good rough method of comparing curvatures for these light models is to take one of uniform curvature which flies straight, and try the effect of flattening one wing. As has been shown, surfaces whose curvature is downwards and above a certain amount (the neutral curvature so called by the writer) are by themselves unstable and have a tendency to twist round, so that, although one of these machines is, as a whole, stable, yet the extended portions of the wings under certain circumstances are unstable and tend to dig down. This effect in some of the lighter models is very marked in a gusty wind, and were it not for this effect, the writer has hardly ever noticed any ill-effects from a strong wind; when well launched the wind is generally a help. Usually, at starting, it will give the machine a lift up of 50 or 60 feet, and if during a flight against the wind there should be an apparent sudden gust (which is not common), the so-called aspiration effect is very marked in giving a lift up. By this, the writer presupposes no mystic power in the air, as it would appear that many do, but effects that can be deduced from Newton's laws, which are quite sufficient even for flying machines.

The steering was originally effected in the models by sliding the back surface to the right, thus putting the drive on to the left of the machine and so driving it round to the right. From the tabulated results it will be seen that about $\frac{3}{8}$″ to the left was sufficient displacement to counteract the general tendency to the right, due to the reaction of the rubber, and another $\frac{1}{4}$″ or so would make the machine take a sweep to the left.

The explanation above has since been found by the writer not to be correct. The general tendency of the machine to go to the right has been found to be not so much due to the reaction of the rubber as to the actual distortion of the frame so caused, causing the surfaces to be in winding relative to each other; means to counteract this can be used to steer the machine.

As to vertical planes, the writer considers that they are worse than useless, as, in order that a machine shall automatically regain the level position after rolling sideways, it must be allowed to slip sideways.

So it is well to note with a wide dihedral angle and high centre of gravity (properly it should coincide with the centre of transverse and longitudinal resistance) we get long, slow rolling. With a sharp dihedral angle and low centre of gravity we get quick rolling and, no doubt, quick and easy recovery, but, at the same time, quick and easy upsetting.

The larger the machines the better they fly; this is very encouraging.

Referring to the tables of flights, the following are points of interest:

Nos. 45-49 show that when flat, undersided surfaces were tried no satisfactory flights were so obtained.

Nos. 71-73.—Here the remarks show the upward inclination of the flight at starting; this is a general characteristic of good flights. The superfluous power of the elastic at starting expends itself in gaining potential energy by rising, which is given out again as the power fails.

No. 84 was a good example of the transverse stability.

The flights on September 23rd were all good; it will be noticed that the substitu-

tion of a 3/ 9// pitch propeller for one of 2/ 4// made practically no difference in the distance flown, although the thrust was considerably reduced and the slip increased.

In No. 116 the wave motion (longitudinal) was very clearly shown, and will be of use in calculating metacentric distances; incidentally it may be noticed that with a man-carrying machine on these lines the period of oscillation (longitudinal) would be about 20 secs.

Nos. 91 to 95 and 124, which were fair flights, would seem to show that in a good flight, at starting, while the machine is being accelerated or driven upwards, the slip is about 20 per cent., and this gradually falls to almost nothing before the rubber is fully unwound, and the writer thinks that 12 per cent. is none too small a proportion to allow for slip when the machine is going well.

No. 129.—501 feet (on a down grade 1 in 25) was the best flight recorded in this series, but a few unrecorded flights with an almost identical machine subsequently by the writer have been better, and at the time of writing he has just heard from a friend that he has had a flight more than half as far again, but this was probably down a steep slope.

In the flight recorded as above the pitch of the propeller was 3/ 9// and diameter about 9//, so that the inclination of the blade to the plane of rotation was considerably more than 45°; in fact, about 56°.

The economy of the motor may be roughly analysed as follows:

Loss in propeller blades due to edge resistance and skin friction ... (*i.e.*, the thrust would be only about 5-6th of what it should be by the formula.)	16%
Loss due to slip	12%
Loss due to friction of bearing	4%
Total loss due to propeller	32%
Loss due to friction and viscosity of the rubber, say	15%
Total loss	47%

After the first stretch rubber loses about 15 per cent. extensibility (as a consequence a new skein of rubber generally adds 60 or 70 feet to the flight), and a further 15 or 20 per cent. is lost after about 20 full windings. Water is of some use to lubricate the rubber and to prevent it from sticking.

Small cut rubber is slightly more efficient than coarse cut, but is more troublesome to keep in a good state.

The machine called No. 2 glider in the tables was a bamboo-built machine of considerable elasticity in its construction, having two pairs of superposed surfaces in tandem, all four being nearly equal and wing-shaped. It was intended subsequently to take a small "Fairy" engine.

The PRESIDENT: This interesting paper is worthy of a long discussion, but I am afraid our time is very short. If any gentleman has anything to say we shall be glad to hear it, if he is rather brief.

Mr. WOOSNAM: I am sure Mr. Clarke's paper raised a great many points that people would like to ask. I should especially like to ask two if he would answer them. Firstly, whether he found that there was any difference between the position of the centre of gravity when the machine was gliding without the action of the propeller and when it was being propelled. I think there must be a difference between the correct position for the centre of gravity in the two cases. It is a question of importance and must appeal to everyone. What is to happen to the machine when it is at a high altitude and the engine stops, as it must occasionally do; will it come down with a rush or glide gently down? Does this not depend upon the position of the centre of gravity? Did Mr. Clarke notice what the *amount* of difference, if any, should be in the correct position for the centre of gravity when the model is driven by the propeller and when it is gliding?

The other question was whether he found that there was any important difference in the distance apart of the two planes—whether there is one particular distance which gives the maximum efficiency, or whether it does not matter a great deal whether the planes are very far apart or not very far apart.

Mr. CLARKE: (1) No difference. In an

FRAMES. Each $3' \times 4\frac{1}{2}''$ Lenticular of $\frac{3}{8}''$ sq. Am. Elm hardwood ends, weight $5\frac{1}{2}$ to $5\frac{3}{4}$ oz. **PROPELLERS.** Special Spoon Shape. Am. Elm.

	Front Surface Seating.			Diameter Area.	Pitch, angle of.	Am. Elm.
A	Parallel to Frame	—	a_1	—	—	
B_1	1° ,, ,,	—	α_2	—	3′ – 9″	
B_2	—	—	β_1	—	—	
B_3	—	—	β_2	—	—	
B_4	—	—	γ	—	2′ – 5″	
C	2° ,, ,,	—	δ	—	1′ – 10″	
D	—	Best relative angle	ϵ	—	2′ – 9″	
E	—	between surfaces	ζ	16 sq. in.	2′ – 4″	
F	—	about $2\frac{1}{2}°$	ι	$12\frac{1}{2}$,,	2′ – 4″	

SURFACES. Max. thickness in each case about $\frac{1}{8}''$ of Silver Spruce.

Letter.	Length across frame.	Breadth, *i.e.*, in direction of frame.	Hollow.	Shape (section).	Dihl. Angle.	Weight.	Area.	Remarks.
A_1	3′ – 10″	$2\frac{1}{2}''$ bare	Flat under		160°	4 oz.	·70 ′	
A_2	Same.	,,	,,		,,	,,	,,	
a_1	2′	$2\frac{1}{8}''$	,,		,,	$1\frac{3}{4}$	·32 ′	**Flat** on the under side
a_2	,,	,,	,,		,,	$1\frac{1}{2}$	,,	
B_1	3′ – 10″	$2\frac{1}{2}''$	$\frac{1}{8}'' = 1/20$		,,	$3\frac{1}{2}$	·70	
B_2	,,	,,	,,		,,	,,	,,	
b_1	2′	$2\frac{1}{8}''$	,,		,,	$1\frac{3}{4}$	·32	Same, with $\frac{1}{8}''$ **hollow**
b_2	,,	,,	,,		,,	,,	,,	
C_1	3′ – 10″	$2\frac{1}{2}''$	$\frac{1}{4}'' = 1/10$		,,	$3\frac{1}{2}$	·70	
C	,,	,,	,,		,,	$4\frac{1}{4}$	,,	Same, with $\frac{1}{4}''$ **hollow**
c_1	2′	$2\frac{1}{8}''$	,,		,,	$1\frac{1}{2}$	·32	
c_2	,,	,,	,,		,,	$1\frac{5}{8}$		
D	4′ – $7\frac{1}{2}''$	$2\frac{7}{8}''$ taper to 1″	1/16″ = 1/25		165°	$3\frac{1}{4}$	·92	Much wider, tapering, very slight hollow, flatter Dihl. Angle, and more area. **A great improvement**
E	,, ?	—	—	,,	,,	—	—	
F_1	,, ?	$2\frac{3}{8}''$ to 1″	3/8 2′ = 1/19	,,	,,	—	—	
G	5′	$4\frac{1}{2}''$ to $1\frac{1}{2}''$	3/16″ bare = 1/20	,,	,,	$7\frac{1}{4}$	1 25	Seemed too big, *i.e.*, not enough $\frac{W}{A}$
g	2′	$2\frac{3}{8}''$	$\frac{1}{8} = 1/18$	,,	,,	$1\frac{1}{2}$	·36	

Referen		Wind.	Frame.	Back Su	Front S	Propelle	Back Surf.	Front Surf.	Back Surf.	Front Surf.	Windin	Elastic.	Torque.	Thl. T Speed	Distance in f	Count.	Seconds	Revs. of	
1	?	?	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Various trials unsatisfactory owing to reaction of Propeller (later more probably due to distortion of frame and looseness of clips), also the whole set too flat.
2	—	—	B_1	D	c_1	$\epsilon 2'\ 9''$	$8''$	$24''$	$2\frac{1}{4}''$ R $= \frac{1}{4}$ R	1 R o see	130 note.	$14 \times \frac{1}{8}$?	?	?	230	36	8	?	Straight, level. Note both surfaces have a latl. Eccentricity to the R. of $2\frac{1}{4}''$ and $1''$ respectively. Expt. subsequently showed that these would neutralise to a great extent, see much later $1''$ R. in front neutralises $2''$ R. behind. Tot. wt. abt. 14oz. = ·86 lb. Tot. area abt. 1·25 sq. ft.
3	—	—	,,	,,	,, ($\frac{1}{4}''$ hollow)	$3'\ 9''$	,,	,,	,,	,,	,,	,,	,,	,,	113	20	4	?	
4	—	—	,,	,,	c_2	$2'\ 9''$	,,	$23\frac{1}{2}$	,,	,,	,,	,,	,,	,,	93	24	5	?	
5	—	—	,,	,,	—	,,	,,	$23\frac{3}{4}$	,,	,,	,,	,,	,,	,,	69	—	—	—	Unsatisfactory.
6	—	—	,,	,,	,,	,,	,,	$23\frac{5}{8}$	$2\frac{1}{8}$ = o	$1\frac{1}{4}$ o	,,	,,	,,	,,	96	27	$4\frac{1}{2}$	—	,, clips probably loose.
7	—	—	,,	,,	,,	,,	,,	$23\frac{1}{2}$	,,	,,	150	$12 \times \frac{1}{8}$	,,	4·8 oz.	66	19	$3\frac{1}{2}$	—	,, ,,
8	—	—	,,	,,	,,	,,	,,	23	,,	,,	,,	,,	—	,,	57	17	3	—	,, ,,
9	—	—	,,	,,	,,	,,	,,	$23\frac{1}{4}$	,,	,,	,,	,,	—	—	270	38	9	—	Sweep R. Note relve. speed abt. 40 or more f.p.s.
10	—	−10	,,	,,	,,	,,	,,	$23\frac{1}{2}$	$2\frac{3}{8}$	,,	,,	,,	—	—	66	23	4	—	
11	—	−10	,,	,,	b_2 ($\frac{1}{8}''$ hollow)	,,	—	$23\frac{3}{4}$	,,	,,	,,	,,	—	—	54 54	77 24	3 $4\frac{1}{2}$	—	Note less hollow in the front surface, giving a better speed.
12	—	,,	,,	,,	,,	,,	8	$23\frac{1}{4}$	$2\frac{1}{4}$ = o	$1\frac{1}{8}$ o	,,	,,	—	—	39	18	3	—	
13	—	—	,,	,,	,,	,,	,,	$22\frac{1}{2}$	,,	,,	,,	,,	—	—	45	15	$2\frac{3}{4}$	—	
14	—	—	,,	,,	,,	,,	,,	22	,,	,,	,,	,,	—	—	69	17	3	—	Fell R.
15	—	—	,,	,,	,,	,,	,,	$21\frac{3}{4}$	,,	,,	,,	,,	—	—	60	19	$3\frac{1}{4}$	—	,,
16	—	—	,,	,,	,,	,,	,,	21	,,	,,	,,	,,	—	—	63	21	$3\frac{1}{2}$	—	,,
17	—	—	,,	,,	,,	,,	,,	$20\frac{1}{2}$	,,	,,	,,	,,	—	—	42	10	2	—	,,
18	—	—	,,	,,	,,	,,	,,	$21\frac{1}{2}$	,,	,,	,,	,,	—	—	42	10	2	—	,,
19	—	—	,,	,,	,,	,,	,,	$21\frac{1}{4}$	1 = $\frac{1}{2}$	$\frac{3}{4}$ o	—	—	—	—	69	10	2	—	Fell L. due to the extra L. eccy.
20	—	—	,,	—	—	—	—	$1''$	$1\frac{1}{2}$	1	—	—	—	—	177 162	on curve on 26 s t.	5	—	big sweep R.
23	?	?	B	D	b_2	$\epsilon 2'\ 9''$	8	$21\frac{1}{4}$	$1\frac{3}{8}$	$\frac{3}{8}$	150	$12 \times \frac{1}{8}$	—	4·8	63	21	3	?	
24	,,	,,	,,	,,	,,	,,	,,	21	,,	1	,,	,,	—	—	102	20	3	—	Straight, considerable rolling.
25	,,	,,	,,	,,	,,	,,	,,	$20\frac{3}{4}$	,,	,,	,,	,,	—	—	132	27	5	—	Improvement by bringing front surface back $\frac{1}{4}''$.
26	,,	,,	,,	,,	,,	,,	,,	$20\frac{1}{4}$	,,	,,	,,	,,	—	—	72	16	2	—	Back too far.
27	,,	,,	,,	,,	,,	,,	,,	$20\frac{5}{8}$	,,	,,	,,	,,	—	—	108	31	6	—	
28	,,	,,	,,	,,	s_1 (flat)	,,	,,	$21\frac{1}{2}$	$1\frac{3}{8}$	$\frac{7}{8}$	,,	,,	—	—	93	—	—	—	V. str. and low.
29	,,	,,	,,	,,	,,	,,	,,	$21\frac{5}{8}$	,,	,,	,,	,,	—	—	69	12	$2\frac{1}{4}$	—	
30	,,	,,	,,	,,	,,	,,	,,	$21\frac{7}{8}$	,,	,,	,,	,,	—	—	93	20	3	—	
31	,,	,,	,,	,,	,,	,,	,,	$21\frac{3}{4}$	,,	,,	,,	,,	—	—	96	22	3	—	
32	Sep. 18/07, on ground 1 in 19 down.	0	B_4	,,	a_1	$\gamma 2'\cdot 12$	,,	$21\frac{1}{2}$	,,	,,	135	,,	3·8oz @ 6″	5·2	—	—	—	—	Rotd. and fell.
33	,,	,,	,,	,,	,,	,,	,,	,,	1	$\frac{1}{2}$	,,	,,	,,	,,	210	33	6	—	V. O. **35 f. p. s.**
34	,,	,,	,,	,,	,,	,,	,,	$21\frac{3}{8}$	,,	,,	150	,,	4·2″	5·7 oz.	162	24	$3\frac{3}{4}$ circ.	80	V. str. down by the head, *i.e.*, front surf. too far back.
35	,,	,,	,,	,,	,,	,,	,,	$21\frac{5}{8}$	,,	,,	160	,,	,,	7 1	264 curv. 230 str.	35	$6\frac{1}{2}$	—	
36	,,	,,	,,	,,	,,	,,	,,	$21\frac{3}{4}$	$1\frac{1}{8}$	$\frac{5}{8}$	,,	,,	5·3	,,	336 300	41	$7\frac{3}{4}$	**174**	*i.e.* **overwound** 14 revs. during the glide at the end (apparent slip = 9 %, but this is due to glide at end).
37	,,	,,	,,	,,	,,	,,	,,	$21\frac{7}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	,,	,,	,,	,,	190 183	—	—	—	By the head.
38	,,	,,	,,	,,	,,	,,	,,	22	$1\frac{3}{8}$	$\frac{5}{8}$	,,	,,	,,	,,	273	40	$7\frac{1}{2}$	155	V. str. **Slip 17 %, no glide.**
39	,,	,,	,,	,,	,,	,,	,,	$22\frac{1}{4}$	,,	,,	,,	,,	,,	,,	288	40	$7\frac{1}{2}$	173	Overwound 13.
40	,,	,,	,,	,,	,,	,,	,,	$22\frac{1}{2}$	,,	,,	,,	,,	,,	,,	150 120	22	$3\frac{1}{4}$	—	Bad launch, bore R.
41	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	309 213	40	$7\frac{1}{2}$	163	Bore L. at finish.
42	,,	,,	,,	,,	,,	,,	,,	$22\frac{7}{8}$	,,	,,	,,	,,	,,	,,	306	41	$7\frac{3}{4}$	172	V. good. **V. similar to 36 and 39.**
43	,,	,,	,,	,,	,,	,,	$7\frac{1}{2}$	$23\frac{7}{8}$	—	—	—	—	—	—	—	—	—	—	Fell by head, back surf. had been slipped $\frac{1}{2}''$ back, and front sur. $1''$ forward.
44	,,	,,	,,	,,	,,	,,	,,	$24\frac{1}{2}$	—	—	—	—	—	—	—	—	—	—	Fell by head evidently not enough, but blocks did not extend sufficiently to put it further.
45	,,	,,	,,	A_1 (flat)	,,	$\gamma 2'\ 4''$	,,	20	$1\frac{3}{8}$	$\frac{5}{8}$	160	$12 \times \frac{1}{8}$	5·3 oz @ 6″	—	69	13	$1\frac{1}{2}$	—	By stern.
46	,,	,,	,,	,,	,,	,,	$6\frac{7}{8}$	$19\frac{1}{8}$	$1\frac{1}{2}$	$\frac{3}{4}$	,,	,,	,,	7·1	—	—	—	—	Bad. **Flat under sides to surfs. No lift in them, all bad.**
47	,,	,,	,,	,,	,,	,,	,,	,,	$1\frac{3}{4}$	$\frac{7}{8}$	,,	,,	,,	,,	51	13	$1\frac{1}{2}$	—	Bad.
48	,,	,,	,,	,,	,,	,,	,,	$19\frac{3}{4}$	,,	,,	,,	,,	,,	,,	—	—	—	—	Bad, seemed to want more drive.
49	,,	,,	,,	,,	,,	,,	,,	20	,,	,,	?	,,	5·7	—	—	—	—	—	Tendency to go tail first.
50	,,	,,	,,	B_1	b_1	,,	7	$20\frac{1}{2}$	,,	,,	160	—	5 3	—	45	—	—	—	Str. and lev. by head. F.S. forwarded $\frac{3}{4}$.
51	,,	,,	,,	,,	,,	,,	,,	$21\frac{1}{4}$	,,	,,	,,	,,	,,	,,	57	12	$1\frac{1}{2}$	—	
53	,,	,,	,,	,,	,,	,,	,,	24	,,	,,	,,	,,	,,	,,	120	20	$2\frac{3}{4}$	—	
54	,,	,,	,,	,,	,,	,,	,,	$24\frac{1}{4}$	,,	,,	,,	,,	,,	,,	96	17	$2\frac{1}{4}$	—	
55	,,	,,	,,	,,	,,	,,	,,	24	$1\frac{7}{8}$	1	,,	,,	,,	,,	60	—	—	—	Str. and lev. at start then cocked up, clips probably loose.
56	,,	,,	,,	,,	,,	,,	,,	$23\frac{3}{4}$	2	1	,,	,,	,,	,,	147	24	$3\frac{3}{4}$	—	
57	,,	,,	,,	,,	,,	,,	,,	$23\frac{1}{2}$	,,	,,	,,	,,	,,	,,	114	26	$4\frac{1}{4}$	—	Became almost vert. at end.
58	,,	,,	,,	,,	,,	,,	,,	23	,,	,,	,,	,,	,,	,,	129	26	$4\frac{1}{4}$	—	,, ,, ,, ,,
59	,,	,,	,,	,,	,,	,,	,,	22	,,	,,	,,	,,	,,	,,	39	9	1	—	Rotd. R.
60	,,	,,	,,	,,	,,	,,	,,	22	,,	,,	,,	,,	,,	,,	54	12	$1\frac{3}{4}$	—	Pitched.
61	,,	,,	,,	,,	,,	,,	,,	$22\frac{1}{4}$	,,	,,	,,	,,	,,	,,	81	14	$1\frac{1}{2}$	—	,,
62	,,	,,	,,	,,	,,	,,	,,	$22\frac{5}{8}$	,,	,,	,,	,,	,,	,,	—	—	—	—	Rotd. R. and broke back surface.
							8	23	$1\frac{7}{8}$	$\frac{7}{8}$	170				81	16	2		
67	,,	,,	,,	,,	,,	,,	,,	,,	$1\frac{1}{2}$	$\frac{5}{8}$	,,	,,	—	—	105	23	$3\frac{1}{4}$	74	

62	,,	,,	,,	,,	,,	,,	8	$22\frac{3}{32}$	,,	$\frac{7}{8}$	170	,,	,,	,,	81	16	2	

67	,,	,,	,,	,,	,,	,,	,,	,,	$1\frac{1}{2}$	$\frac{5}{8}$	,,	,,	—	—	105	23	$3\frac{1}{2}$	74	,,
68	,,	,,	,,	,,	,,	,,	,,	$23\frac{1}{4}$	$1\frac{1}{2}$	,,	,,	,,	—	—	147	30	$5\frac{3}{4}$	—	Str.
69	,,	,,	,,	,,	,,	,,	,,	$23\frac{3}{8}$	,,	,,	,,	,,	—	—	207	40	$7\frac{1}{2}$	169	Str. v. Good, rose about 1 in 6.
70	,,	−1	,,	,,	,,	δ 1′ 10″	,,	,,	,,	,,	170	,,	—	—	210	30	$5\frac{1}{2}$	163	
71	,,	,,	,,	,,	,,	,,	,,	24	,,	,,	,,	,,	—	—	192	34	$6\frac{1}{4}$	170	**Rose about 1 in 4.**
72	,,	,,	,,	,,	,,	,,	,,	$24\frac{1}{8}$	,,	,,	,,	,,	—	—	222 / 159	37	7	180	**Rose about 1 in 3, turned L. when at highest.**
73	,,	−4	,,	,,	,,	,,	,,	$23\frac{1}{8}$	,,	,,	172	,,	—	—	150	33	6	154	**Rose about 1 in 6.**
74	,,	,,	,,	,,	,,	,,	,,	23	,,	,,	,,	,,	—	—	138	30	$5\frac{1}{2}$	142	
75	,,	0	,,	,,	,,	,,	,,	$23\frac{1}{2}$	,,	,,	,,	,,	—	—	135	24	$5\frac{3}{4}$	99	
76	,,	,,	,,	,,	,,	,,	,,	24	,,	,,	,,	,,	—	—	201 / 141	29	$5\frac{1}{4}$	142	
77	,,	+2	,,	,,	,,	,,	,,	,,	,,	,,	208	$10\times\frac{1}{8}$	—	—	129	20	$2\frac{3}{4}$	—	
78	,,	−3	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	117	13	$5\frac{1}{2}$	120	
79	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	54	19	$2\frac{1}{2}$	—	Fell, L.
80	,,	−2	,,	,,	,,	,,	,,	,,	,,	,,	200	,,	—	—	84	22	$3\frac{1}{4}$	—	
81	,,	,,	,,	,,	,,	,,	,,	$23\frac{1}{2}$	,,	,,	198	,,	—	—	126	23	$3\frac{1}{2}$	—	Bad launch, but righted itself, rolled 6ft. sideways and back.
82	,,	+1	,,	,,	,,	,,	,,	,,	,,	,,	163	—	—	—	—	—	—	—	2 Bad flights, fell L.
83	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	—	159	24	$3\frac{3}{4}$	100	
84	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	—	198	25	4	—	**Recovered from about 80° roll.**
85	,,	0	,,	,,	a_1	,,	,,	22	,,	,,	,,	—	—	—	78	14	$1\frac{3}{4}$	47	Vibrated, probably propeller not centred.
86	,,	,,	,,	,,	,,	,,	,,	$22\frac{1}{2}$	‖ ,,	,,	172	—	—	—	180	29	$5\frac{1}{4}$	—	
87	,,	,,	,,	,,	a_1 (flat)	,,	,,	$22\frac{3}{4}$	,,	,,	,,	$10\times\frac{1}{8}$	—	45	123	20	$2\frac{3}{4}$	—	
88	,,	,,	—	—	—	—	—	$23\frac{1}{4}$	$1\frac{3}{8}$	$\frac{5}{8}$	165	—	—	40	219	30	$5\frac{1}{2}$	—	Forward propeller bearing carried away; discarded in future.
89	,,	,,	—	—	—	—	—	$23\frac{3}{4}$	—	—	161	—	—	44	267	33	6	167	Good. Apparent slip 13%, but note glide.
90	,,	—	—	—	—	γ 2′ 4″	8	22	—	—	156	—	—	54	108	16	2	—	By the head.
91	,,	—	—	—	—	—	—	$22\frac{1}{2}$	—	—	,,	—	—	46	150	22	$3\frac{1}{4}$	80	Cocked up in launching. Slip 20%.
92	,,	—	—	—	—	—	—	$23\frac{1}{2}$	—	—	,,	—	—	36	126	23	$3\frac{1}{2}$	—	
93	,,	—	—	—	—	—	—	,,	—	—	172	—	—	43	246	32	$5\frac{3}{4}$	130	Slip 16%.
94	,,	—	—	—	—	—	—	24	—	—	180	—	—	50	291 / 243	32	$5\frac{3}{4}$	138	Driving all the time, slip 10%,
95	,,	—	—	—	—	—	—	$24\frac{1}{4}$	—	—	184	—	—	46	162	23	$3\frac{1}{2}$	84	,, ,, ,, ,, 19%. Speed in above, say, 44 f.p.s., and was but slightly altered by increasing the pitch of the propeller. Slip 20%, failing considerably below 10% before the elastic was $\frac{3}{4}$ outwound.
96	Sunday, Sep. 23/07	−9	Two	flights	with	a twin	screw	machine		B_1	B_2	—	—	31	159	29	$5\frac{1}{4}$	87	
97	,,	−2	—	—	—	$\beta_1\beta_2$	—	—	—	—	—	—	—	42	105	18	$2\frac{1}{2}$	—	
98	Sep. 26/07	0	E_4	E_1	a_1	β_2	$7\frac{1}{4}$	$21\frac{1}{2}$	$1\frac{1}{8}$	$\frac{5}{8}$	180	$10\times\frac{1}{8}$	—	—	—	—	—	—	Went steadily up, but lost velocity and dived.
99	,,	—	—	—	—	—	—	22	—	—	120?	—	—	—	70	—	—	—	Relve. incln. of surfs. probably too great with this frame.
100	—	—	—	—	—	—	—	23	—	—	—	—	—	—	—	—	—	—	
101	—	—	—	—	—	—	$7\frac{1}{2}$	$21\frac{1}{2}$	—	—	200	—	—	—	100	—	—	—	Seemed to want more power.
102	—	—	—	—	—	—	$7\frac{3}{4}$	$22\frac{1}{2}$	$1\frac{3}{8}$	,,	220	—	—	—	120	—	—	—	
103	—	—	—	—	—	—	$7\frac{7}{8}$	22	—	—	—	—	—	—	—	—	—	—	By the head.
104	—	—	—	—	—	—	,,	$22\frac{1}{2}$	—	—	220	—	—	—	—	—	—	—	
105	—	—	—	—	—	—	—	$23\frac{1}{2}$	—	—	,,	—	—	63	130	—	—	—	
106	—	—	—	—	—	—	—	$24\frac{1}{2}$	—	—	—	—	—	58	130	—	—	—	
107	—	—	—	—	—	—	—	$25\frac{1}{2}$	$1\frac{1}{2}$	$\frac{3}{4}$	120	$12\times\frac{1}{8}$	—	61	117	—	—	—	
108	—	—	—	C_1	c_2	—	$7\frac{3}{4}$	24	,,	,,	,,	,,	—	—	—	—	—	—	Completely upset.
109	Sept. 23/07 contd.	0	F	F_1 3/32 hollow, $2\frac{3}{8}$ max. width	f_1	‹ 2′ 4″ $12\frac{1}{2}$ sq.″	9″	27″	,,	,,	190	$12\times\frac{1}{8}$	6 oz × 6″	8 oz.	—	30	$5\frac{1}{2}$	—	**Frictional Torque** when fully wound = $\frac{1}{4}$oz. × 6″ = 4 p.c.
110	,,	,,	,,	,,	,,	,,	,,	$26\frac{1}{2}$	,,	,,	,,	,,	,,	—	—	54	$11\frac{1}{2}$	—	Big circle to R.
111	,,	,,	,,	,,	,,	,,	,,	26	1	$\frac{1}{2}$	184	,,	,,	—	—	39	$7\frac{1}{2}$	—	
112	,,	,,	,,	,,	,,	,,	,,	,,	$\frac{1}{8}$	0	190	,,	,,	—	—	23	$3\frac{1}{2}$	—	
113	,,	+2	,,	,,	,,	,,	,,	25	$\frac{1}{8}$	$\frac{1}{8}$	,,	,,	,,	29	330	54	$11\frac{1}{2}$	184	L.
114	,,	+3	,,	,,	,,	,,	,,	24	$\frac{1}{8}$	$\frac{1}{8}$	,,	,,	,,	37	486	60	$13\frac{1}{4}$	196	R.
115	,,	+2	,,	,,	,,	,,	,,	$23\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{4}$	,,	,,	,,	43	462	52	$10\frac{1}{2}$	,,	L.
116	,,	,,	,,	,,	,,	,,	,,	23	$\frac{1}{2}$	$\frac{1}{4}$	186	,,	,,	35	414	56	12	195	Slightly R. **Three Waves amplitude about 120′**
117	,,	0	,,	,,	,,	,,	,,	$22\frac{1}{2}$	$\frac{1}{8}$	0	189	,,	,,	—	—	—	—	—	Fouled a tree.
118	,,	,,	,,	,,	,,	,,	,,	22	$\frac{1}{4}$	,,	,,	,,	,,	32	354	53	11	193	Str. shallower waves.
119	,,	,,	,,	,,	,,	,,	,,	$21\frac{1}{8}$	$\frac{1}{4}$	,,	190	,,	,,	31	369	56	12	190	

67	,,	,,	,,	,,	,,	,,	,,	,,	$1\frac{1}{2}$	$\frac{3}{8}$	,,	,,	—	—	105	23	$3\frac{1}{8}$	74	,,
68	,,	,,	,,	,,	,,	,,	,,	$23\frac{1}{4}$	$1\frac{1}{4}$	,,	,,	,,	—	—	147	30	$5\frac{3}{8}$	—	Str.
69	,,	,,	,,	,,	,,	,,	,,	$23\frac{1}{2}$	,,	,,	,,	,,	—	—	207	40	$7\frac{1}{2}$	169	Str. v. Good, rose about 1 in 6.
70	,,	−1	,,	,,	,,	δ 1′ 10″	,,	,,	,,	,,	170	,,	—	—	210	30	$5\frac{1}{2}$	163	
71	,,	,,	,,	,,	,,	,,	,,	24	,,	,,	,,	,,	—	—	192	34	$6\frac{1}{4}$	170	**Rose about 1 in 4.**
72	,,	,,	,,	,,	,,	,,	,,	$24\frac{1}{8}$	,,	,,	,,	,,	—	—	222 / 159	37	7	180	**Rose about 1 in 3, turned L. when at highest.**
73	,,	−4	,,	,,	,,	,,	,,	$23\frac{1}{8}$	,,	,,	172	,,	—	—	150	33	6	154	**Rose about 1 in 6.**
74	,,	,,	,,	,,	,,	,,	,,	23	,,	,,	,,	,,	—	—	138	30	$5\frac{1}{2}$	142	
75	,,	0	,,	,,	,,	,,	,,	$23\frac{1}{2}$	,,	,,	,,	,,	—	—	135	24	$5\frac{3}{4}$	99	
76	,,	,,	,,	,,	,,	,,	,,	24	,,	,,	,,	,,	—	—	201 / 141	29	$5\frac{1}{4}$	142	
77	,,	+2	,,	,,	,,	,,	,,	,,	,,	,,	208	$10\times\frac{1}{8}$	—	—	129	20	$2\frac{3}{4}$	—	
78	,,	−3	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	117	13	$5\frac{1}{2}$	120	
79	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	54	19	$2\frac{1}{2}$	—	Fell, L.
80	,,	−2	,,	,,	,,	,,	,,	,,	,,	,,	200	,,	—	—	84	22	$3\frac{1}{4}$	—	
81	,,	,,	,,	,,	,,	,,	,,	$23\frac{1}{2}$	,,	,,	198	,,	—	—	126	23	$3\frac{1}{2}$	—	Bad launch, but righted itself, rolled 6ft. sideways and back.
82	,,	+1	,,	,,	,,	,,	,,	,,	,,	,,	163	—	—	—	—	—	—	—	2 Bad flights, fell L.
83	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	—	159	24	$3\frac{3}{4}$	100	
84	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	—	—	—	198	25	4	—	**Recovered from about 80° roll.**
85	,,	0	,,	,,	a_1	,,	,,	22	,,	,,	,,	—	—	—	78	14	$1\frac{1}{2}$	47	Vibrated, probably propeller not centred.
86	,,	,,	,,	,,	,,	,,	,,	$22\frac{1}{2}$	,,	,,	172	—	—	—	180	29	$5\frac{1}{4}$	—	
87	,,	,,	,,	,,	a_1 (flat)	,,	,,	$22\frac{3}{4}$	,,	,,	,,	$10\times\frac{1}{8}$	—	45	123	20	$2\frac{3}{4}$	—	
88	,,	,,	—	—	—	—	—	$23\frac{1}{4}$	$1\frac{3}{8}$	$\frac{5}{8}$	165	—	—	40	219	30	$5\frac{1}{2}$	—	Forward propeller bearing carried away; discarded in future.
89	,,	,,	—	—	—	—	—	$23\frac{3}{4}$	—	—	161	—	—	44	267	33	6	167	Good. Apparent slip 13%, but note glide.
90	,,	—	—	—	—	γ 2′ 4″	8	22	—	—	156	—	—	54	108	16	2	—	By the head.
91	,,	—	—	—	—	—	—	$22\frac{1}{2}$	—	—	,,	—	—	46	150	22	$3\frac{1}{4}$	80	Cocked up in launching. Slip 20%.
92	,,	—	—	—	—	—	—	$23\frac{1}{2}$	—	—	,,	—	—	36	126	23	$3\frac{1}{2}$	—	
93	,,	—	—	—	—	—	—	,,	—	—	172	—	—	43	246	32	$5\frac{3}{4}$	130	Slip 16%.
94	,,	—	—	—	—	—	—	24	—	—	180	—	—	50	291 / 243	32	$5\frac{3}{4}$	138	Driving all the time, slip 10%.
95	,,	—	—	—	—	—	—	$24\frac{1}{4}$	—	—	184	—	—	46	162	23	$3\frac{1}{2}$	84	,, ,, ,, ,, 19%. Speed in above, say, 44 f.p.s., and was but slightly altered by increasing the pitch of the propeller. Slip 20%, falling considerably below 10% before the elastic was $\frac{3}{4}$ outwound.
	Sunday,																		
96	Sep. 23/07	−9	Two	flights	with	a twin	screw	machine		B_1	B_2	—	—	31	159	29	$5\frac{1}{4}$	87	
97	,,	−2	—	—	—	$\beta_1\beta_2$	—	—	—	—	—	—	—	42	105	18	$2\frac{1}{2}$	—	
98	Sep. 26/07	0	E_4	E_1	a_1	β_2	$7\frac{1}{4}$	$21\frac{1}{2}$	$1\frac{3}{8}$	$\frac{5}{8}$	180	$10\times\frac{1}{8}$	—	—	—	—	—	—	Went steadily up, but lost velocity and dived.
99	,,	—	—	—	—	—	—	22	—	—	120?	—	—	—	70	—	—	—	Relve. incln. of surfs. probably too great with this frame.
100	—	—	—	—	—	—	—	23	—	—	—	—	—	—	—	—	—	—	
101	—	—	—	—	—	—	$7\frac{1}{2}$	$21\frac{1}{2}$	—	—	200	—	—	—	100	—	—	—	Seemed to want more power.
102	—	—	—	—	—	—	$7\frac{3}{4}$	$22\frac{1}{2}$	$1\frac{3}{8}$	,,	220	—	—	—	120	—	—	—	
103	—	—	—	—	—	—	$7\frac{1}{8}$	22	—	—	—	—	—	—	—	—	—	—	By the head.
104	—	—	—	—	—	—	,,	$22\frac{1}{2}$	—	—	220	—	—	—	—	—	—	—	
105	—	—	—	—	—	—	—	$23\frac{1}{2}$	—	—	,,	—	—	63	130	—	—	—	
106	—	—	—	—	—	—	—	$24\frac{1}{2}$	—	—	—	—	—	58	130	—	—	—	
107	—	—	—	—	—	—	—	$25\frac{1}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	120	$12\times\frac{1}{8}$	—	61	117	—	—	—	
108	—	—	—	C_1	c_2	—	$7\frac{3}{4}$	24	,,	,,	,,	,,	—	—	—	—	—	—	Completely upset.
109	Sept. 23/07 contd.	0	F	F_1 3/32 hollow, $2\frac{3}{8}$ max. width	f_1	2′ 4″ $12\frac{1}{2}$ sq.″	9″	27″	,,	,,	190	12 × $\frac{1}{8}$	6 oz × 6″	8 oz.	—	30	$5\frac{1}{2}$	—	**Frictional Torque** when fully wound = $\frac{1}{4}$oz. × 6″ = 4 p.c.

	contd.			3/32 hollow, $2\frac{3}{8}$ max. width		$12\frac{1}{2}$ sq."							× 6"					wound = $\frac{1}{4}$oz. × 6" = 4 p.c.
110	,,	,,	,,	,,	,,	,,	,,	$26\frac{1}{2}$	,,	,,	,,	,,	,,	—	—	54	$11\frac{1}{2}$	—	Big circle to R.
111	,,	,,	,,	,,	,,	,,	,,	26	1	$\frac{1}{2}$	184	,,	,,	—	—	39	$7\frac{1}{2}$	—	
112	,,	,,	,,	,,	,,	,,	,,	,,	$\frac{1}{8}$	0	190	,,	,,	—	—	23	$3\frac{1}{2}$	—	
113	,,	+2	,,	,,	,,	,,	,,	25	$\frac{1}{8}$	$\frac{1}{8}$	,,	,,	,,	29	330	54	$11\frac{1}{2}$	184	L.
114	,,	+3	,,	,,	,,	,,	,,	24	$\frac{1}{8}$	$\frac{1}{4}$	,,	,,	,,	37	486	60	$13\frac{1}{2}$	196	R.
115	,,	+2	,,	,,	,,	,,	,,	$23\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{4}$	,,	,,	,,	43	462	52	$10\frac{3}{4}$	,,	L.
116	,,	,,	,,	,,	,,	,,	,,	23	$\frac{1}{2}$	$\frac{1}{4}$	186	,,	,,	35	414	56	12	195	Slightly R. **Three Waves amplitude about 120'**
117	,,	0	,,	,,	,,	,,	,,	$22\frac{1}{2}$	$\frac{1}{2}$	0	189	,,	,,	—	—	—	—	—	Fouled a tree.
118	,,	,,	,,	,,	,,	,,	,,	22	$\frac{1}{4}$	,,	,,	,,	,,	32	354	53	11	193	Str. shallower waves.
119	,,	,,	,,	,,	,,	,,	,,	$21\frac{1}{2}$	$\frac{1}{4}$	,,	190	,,	,,	31	369	56	12	190	
120	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	38	393	50	$10\frac{1}{2}$	193	Launched by Mr. Bennett.
121	,,	,,	,,	,,	,,	,,	,,	$21\frac{1}{4}$	,,	,,	,,	,,	,,	35	420	56	12	190	Ditto, ditto, slighting R.
122	,,	,,	,,	,,	,,	,,	,,	21	,,	,,	185	,,	,,	35	336	48	$9\frac{1}{2}$	190	Launched by Pat.
123	,,	,,	,,	,,	,,	ζ. 2' 4" 16 sq.'	,,	19	,,	,,	184	,,	,,	38	414	53	11	—	L 3° (1 in 19) fall from eye to spot.
124	,,	,,	,,	,,	,,	,,	,,	$18\frac{1}{2}$	$\frac{3}{8}$	,,	190	,,	,,	40	423 } −6 } slide	50	$10\frac{1}{4}$	181	Str. **Slip 1 p.c. (apparently).**
125	,,	,,	,,	,,	,,	,,	,,	$18\frac{5}{8}$	$\frac{3}{8}$	,,	192	,,	,,	44	410 ? 415 ? ζ	48	$9\frac{1}{2}$	168	R. Slip 6 p.c. (apparently). Distances queried were evidently too big.
126	,,	,,	,,	,,	,,	,,	,,	$18\frac{3}{4}$	,,	,,	196	,,	,,	—	—	—	—	—	Bad R., probably trigger-pin stuck through over winding.
127	,,	,,	,,	,,	,,	α_2 3' 9"	,,	19	,,	,,	190	,,	,,	5 oz. 39	363	47	$9\frac{1}{4}$	183	St.
128	,,	,,	,,	,,	,,	,,	,,	$19\frac{1}{2}$	,,	,,	187	,,	,,	,, 40	425	52	$10\frac{3}{4}$	195	L. **Changed the Rubber.**
129	,,	,,	,,	,,	,,	,,	,,	$19\frac{1}{4}$	$\frac{1}{2}$	,,	189	,,	,,	,, 49	*501	50 ?	$10\frac{1}{4}$?	195	R. **Best recorded flight about 1 in 25 falling ground.**
130	,,	,,	,,	,,	,,	,,	,,	,,	$\frac{7}{16}$	,,	188	,,	,,	,, 48	309	36	$6\frac{1}{2}$	—	L. Level ground.
131	,,	,,	,,	,,	,,	,,	,,	$19\frac{3}{8}$	,,	,,	195	,,	,,	40	321	42	8	—	Str. ,, ,,
132	?	+15?	B_4	G_1 3/16 hol low.	g	β_1	,,	18	$\frac{1}{4}$	,,	200	$10\times\frac{1}{8}$	—	—	87	23	$3\frac{1}{2}$	70?	**Strong wind, rapid rise.** (so-called aspiration).
133	,,	14	,,	,,	,,	,,	,,	$17\frac{3}{4}$	$\frac{1}{8}$	,,	200	,,	—	—	78	22	$3\frac{1}{4}$	—	
134	—	15	,,	,,	,,	,,	,,	$17\frac{1}{2}$	0	,,	,,	,,	—	—	93	22	$3\frac{1}{4}$	80	
135	—	20	,,	,,	,,	,,	,,	$18\frac{5}{8}$	,,	,,	,,	,,	—	—	54	18	$2\frac{1}{2}$	—	
136	—	—	,,	,,	,,	,,	,,	$17\frac{1}{4}$	,,	,,	,,	,,	—	—	—	—	—	—	Fell R.
137	—	18	,,	,,	,,	,,	,,	$17\frac{1}{2}$	,,	,,	,,	,,	—	—	99	27	$4\frac{1}{2}$	—	Rapid rise then fell by head.
138	—	12	,,	,,	,,	,,	,,	$17\frac{3}{8}$	,,	,,	,,	,,	—	—	99	26	$4\frac{1}{2}$	—	
139	—	9	,,	,,	,,	,,	,,	18	$\frac{1}{4}$	,,	190	$12\times\frac{1}{8}$	—	—	150	30	$5\frac{1}{2}$	—	
140	—	8	,,	,,	,,	,,	,,	$18\frac{1}{2}$	,,	,,	179	,,	—	—	132	26	$4\frac{1}{2}$	79	
141	—	6	,,	,,	,,	,,	,,	19	$\frac{1}{4}$	,,	,,	,,	—	—	144	30	$5\frac{1}{2}$	—	
142	—	2	,,	,,	,,	,,	,,	$19\frac{1}{2}$	,,	,,	172	,,	—	—	183	34	$6\frac{1}{4}$	—	
143	—	,,	,,	,,	,,	,,	,,	20	,,	,,	,,	,,	—	—	102	20	$2\frac{3}{4}$	57	
144	—	,,	,,	,,	,,	,,	,,	$20\frac{1}{2}$	,,	,,	,,	,,	—	—	180	37	7	—	
145	—	0	,,	,,	,,	,,	,,	$21\frac{1}{2}$	,,	,,	,,	,,	—	—	210	37	7	84	
146	—	,,	,,	,,	,,	,,	,,	$22\frac{1}{4}$	,,	,,	,,	,,	—	—	147	26 ?	$4\frac{1}{2}$?	—	Caught in Fir tree.
147	—	,,	,,	,,	,,	,,	,,	22	,,	,,	180	,,	—	—	159	30	$5\frac{1}{2}$	78	New elastic.
148	—	,,	,,	,,	,,	,,	,,	$22\frac{1}{2}$	,,	$\frac{1}{4}$	,,	,,	—	—	183 } 148 }	30	$5\frac{1}{2}$	—	R.
149	—	,,	,,	,,	,,	,,	,,	,,	,,	$\frac{1}{2}$	,,	—	—	—	252	42	—	168	Rose again.
150	—	,,	,,	,,	,,	,,	,,	$22\frac{3}{4}$	,,	1	—	—	—	—	—	27	—	—	Curved R sharp at end.
151	—	,,	,,	,,	,,	,,	,,	,,	$\frac{3}{4}$	0	—	—	—	—	—	—	—	—	Curved L. about 30' rad.

— means following wind. + means head wind.

$\left.\begin{matrix}201\\141\end{matrix}\right\}$ means 201' as measured along the actual path (curved) travelled, and 141' from start to finish in a direct line.

109 to 126.—In above total weight of machine, 1·25 lbs. } $\frac{W}{A}$ = 0·83 lbs. sq.'
,, ,, ,, area, 1·5 ,, }

* Mr. Hargraves best published flight for **rubber-driven** models, 270 feet, on level ground.

H.P. developed by Rubber, 0·02 approx.; H.P. used by Machine, 0·009 approx. (*i.e.*, **W = 62 lbs. or 137 lbs. per Horsepower).**

No. 2 GLIDER.

TWINDECKERS IN TANDEM.

WEIGHT, 58 lbs. EMPTY. AREA, about 70 sq. ft.

BALANCE, Empty. 8″ ahead of central vert. strut.

" with 4 lbs. extra on front edge of sail, 11″ ahead of central vert. strut.

Front edge of sail is 11½″ ahead of central vert. strut.

Front edge of sail is 52″ ahead of central vert. strut. (32″ to sail and 20″ sail).

SUNDAY, OCTOBER 13. Set to Template.

Glide 350′ on curve. } count 61 = 13½ sec. against 8 m.p.h. (12 f.p.s.) breeze.
243′ on straight. }

350′ in 13½ secs. = 26 f.p.s.
12

Velocity in air 38 f.p.s.

$$\text{Load} = \frac{62}{70} = \cdot 9 \text{ lbs. sq.}'$$

A SMALLER MODEL. WEIGHT 7½ oz. = ·47 lb. Area 1 sq.′ Back surface set over 1″ R. Pitch of Propr. 2′ 10″.

Flight.	Count.	Time secs.	Elastic.		Remarks.
70′	—	7 ?	—		Turned L sharp.
70′	—	"	—		" " "
270′	57	12	—	22½	v. straight (142 + 8) Revs.
93	32	6	—	16	Badly launched.
108	34	6¼	—	17	Against fair wind L.
57	13	1½	10 × ⅛		
190	—		"		
249	—		"		L (121 + 6) Revs.
(450)					Finish 10′ above start.
225	40	7½	8 × ⅛		(125 + 7) Revs.
(360)					
327	50	10¼	"		(175 − 67) "

Flight in feet.	Count.	Time.	Speed f.p.s.	Remarks.
345	55	11½	30	Distance probably in excess.
360	50	10¼	35	
309	47	9¼	34	
255	45	8¾		
(450)				
234	52	10¾	22	
290	39	7¼	40	

SMALLER MODEL. Length one foot. Pitch about 1′ 7″.

Weight.	Area.	Flight.	Count.	Time.	Speed. f.p.s.	Hollow.
(1) ·05 lb.	·31 sq′	63′	26	4¼	15	about $\frac{1}{12}$ width.
(2) ·065 "	"	66′	22	3¾	20	

ordinary good flight the rubber runs right out while high up, and the machine glides down, over-winding the propeller while doing so, as in No. 36. The propeller in these cases, of course, causes a considerable resistance, and, owing to this and also that the speed is somewhat less, the gliding part of the flight is not so steady as that part during which the machine is being propelled. In order that a machine shall continue to glide after the thrust has ceased the line of action of this thrust must approximately coincide with the resultant resistance (longitudinal) of the framing and surfaces; if it be considerably below it the machine is bound to pitch forward when the thrust ceases (and also to pitch in gusty weather). In the models the thrust could probably, with advantage, be placed higher, but this would buckle the frame. No. 124 also shows that the machine came down so flat (on a road), after a good flight, that it slid forward six feet. (2) I have not noticed that any particular distance gives the maximum efficiency, but I find that, as might be expected, the farther they are apart the better; the wave-length of the trajectory is longer and the flight is steadier, and, consequently, longer as well. But, on the other hand, with models in which the front surface is too large and the curvature too great, I have noticed certain peculiarities which might be accounted for by considerations of wave phase as suggested by Mr. Woosnam.

The PRESIDENT: Has any other gentleman anything to say? You have seen these beautiful models in another place and on another occasion.

Mr. CODY: I should like to say a few words if I may, Mr. Chairman, and Ladies and Gentlemen. I am a great admirer of men of deeds and not of words. Consequently I admire Mr. Clarke's work very much, and expressed my opinion to Mr. Clarke when I first made his acquaintance. He is a man who struggles hard, and he has turned out something very valuable I think. If he could only turn it out larger I should very much like to see it. I am an experimenter in the same way, perhaps a jealous one, too, but I cannot help but admire a good thing when I see it. I have heard him talk to-night more than ever I have before, and I have known him a long time. (Laughter.) A man who does a thing and lets somebody else talk about it. He doesn't give himself half the credit he deserves. (Applause.)

The PRESIDENT: I am sure we all endorse every word that Mr. Cody has said, and we are exceedingly obliged to Mr. Clarke, as we are to the authors of the other papers. I am afraid we must go on to the next.

Owing to the absence of Mr. Lloyd, the Hon. Secretary read his paper.

Notes on the Present Position of Mechanical Flight in France.

By HERBERT F. LLOYD.

For more than a century past the problem of human flight by means of heavier-than-air machines appears to have exercised a strong fascination on the minds of French inventors and engineers, and since November, 1906, as the result of Santos Dumont's classic experiments, and more recently the longer successful flights of Henri Farman and Léon Delagrange, even the general public has become interested in the subject, and has at last been taught to realise that dynamic flight is not only a possibility, but a fact, and that with each day which passes the success already attained is being steadily carried another step forward towards the evolution of the eventual type of perfected machine.

If we except the performances of the Brothers Wright in America, it is admitted that France has led, and is still leading, the aëronautical progress of the world, and it is not difficult to understand why this should be the case. Her engineers seem to possess a peculiar aptitude for this special branch of science, and her War Department has always been foremost in the design and application of balloons and dirigible airships, etc., to military requirements; also her progress in automobilism, and the consequent attention paid to the improvement of the petrol motor, has brought about the production of the special type of engine demanded for aëronautical purposes. But, perhaps, the greatest

factor of all has been the unprecedented stimulus to private enterprise and the generous assistance to experimenters which has been afforded by the public-spirited support of such men as MM. Archdeacon and Deutsch de la Meurthe (who have probably done more than any-one else to encourage the development of aërial flight), Comte de la Vaulx, Armengaud, Michelin, and others.

At present, although the success of the few may have to some extent disheartened other aviators, the number of machines already built or in hand is certainly greater than at any previous date. There are now said to be more than 150 experimenters at work in France, out of which not more than 10 have as yet achieved any decisive result with man-carrying machines. Interest is chiefly concentrated at the moment on the aëroplane type, the best known being the machines of Farman and Delagrange, designed and constructed by the Brothers Voisin. During the last few months the writer has paid many visits to the historic military manœuvre ground at Issy-les-Moulineaux to witness their experiments, and it is, indeed, a most inspiring sight to see these splendid machines sweeping through the air in immense circles kilometre after kilometre. The fore and aft stability regulated by the box-tail and front steering plane seems to be almost perfect, and when the propeller is stopped, the apparatus glides smoothly to the ground; but the lateral stability is not so good, especially in making a sharp turn, or even in a light cross wind, when there is a pronounced and somewhat dangerous sideways tilt caused by the difference in lift between the inner and outer sets of planes. M. Farman himself does not profess to have solved the question of perfect equilibrium under all conditions, and these machines are only taken out on days when there is little or no wind, and when the ground surface is sufficiently dry and hard for an effective initial run, and it is obvious that, though they may possess adequate stability in calm air, they are as yet unfitted for use in rough weather. It is, therefore, difficult to believe that there is much hope of perfect equilibrium ever being successfully obtained in disturbed air for the large inert fixed surfaces inherent to the aëroplane system without some radical modification in design.

The achievements, however, of Farman and Delagrange, besides providing valuable data for other workers, show us that useful results can only be obtained by patient and protracted trials and gradually acquired skill, and our deepest admiration goes out to these men for the difficulties which they have overcome and for the great impetus which they have given to the science of flight. But it must also not be forgotten that a large portion of their success has been due to the ingenious design and sound construction which characterises the work of Charles and Gabriel Voisin, and which is the result of knowledge gained from their many years of practical experience in the art of flying. It is an education in itself to inspect their work, to observe the minute attention paid to details affecting air resistance, etc., and the manner in which the requisite strength has been combined with extreme lightness.

Messrs. Voisin are now engaged in the completion of Farman's monoplane, "The Flying Fish," which will be ready for its preliminary trials in a few weeks; the sustaining surfaces consist of five pairs of narrow wings mounted *en escalier* on a central framework 14 m. long; the 2-bladed propeller in front is driven through reduction gear at 1,100 r.p.m. by an 8-cylinder "V" Renault motor giving 47-H.P. at propeller blades; the weight of the motor complete is 143 kilos., and of the whole machine 600 kilos.; it is expected to exceed a speed of 60 miles per hour.

They also have in hand at their works near Billancourt some more aëroplanes of the same type as the Farman No. 1, and several machines on what may be called the 3-plane system, in which the sustaining surfaces are built up of three superimposed planes, with 2-bladed propeller in front. The first of these should be ready for experimental work about the end of June.

They also propose to construct a motor car driven by an air propeller behind and fitted with fixed planes extending along the sides of the body to the rear in order to give buoyancy—in short, a flying machine with the wheels in continual contact with the ground. Though an interesting experiment, such a machine would probably be difficult to control, owing to decreased road adhesion, and the pro-

peller would raise clouds of dust and sweep it into the adjacent houses and fields. It may be recalled that M. Ernest Archdeacon, in 1906, built and experimented with a motor bicycle driven by a propeller, and a speed of 48 miles per hour is said to have been attained.

Dealing briefly with other aviators, M. Santos Dumont's efforts during the past year seem to have been frustrated by ill-fortune, and his recent experiments have not yet produced much favourable result.

M. Louis Blériot, that indefatigable investigator, who has built so many machines, and who made several flights on one of his monoplanes up to 400 and 500 m. in November and December, 1907, has also experienced mishaps and continual breakages, which, however, have probably been of great practical value in assisting him to eliminate possible causes of failure, which can only be discovered by actual flights. After carrying out certain important improvements in his latest machine, he has taken possession of the new sheds which he has just built in the Aëro Club's parc d'aviation at Issy-les-Moulineaux, where he will now resume his experiments.

M. Robert Esnault-Lelterie, whose work is distinguished by such originality of design, is the inventor of the well-known R.E.P. motor, which has seven cylinders disposed starwise round a central crank-chamber without any fly-wheel. He has made many successful short flights, and is now experimenting at Buc, near Versailles, with his latest machine, and it is probable that he will shortly obtain some interesting results.

MM. Gastembide and Mengin's bird-like monoplane, driven by a 50-H.P. Antoinette motor, turned over during flight in February, 1908, and was wrecked, probably owing to defective stability and absence of horizontal steering plane. Towards the end of March, 1908, trials were resumed, but the machine was unable to leave the ground, and further experiments appear to have been temporarily abandoned.

M. Pischoff, whose aëroplane, with propeller in front, is fitted with a 3-cylinder 25-H.P. Anzani motor, made several short flights in January, 1908, but the machine was wrecked through the wheels giving way. He is now said to be at work on a new and improved aëroplane.

The monoplane of Levarasseur and Ferber is of somewhat peculiar design, with two large concave pointed wings and a 100-H.P. 16-cylinder Antoinette motor. It is one of the most powerfully-engined aëroplanes which have yet been made in France, and is now approaching completion in the Antoinette workshops.

M. Henri Kapferer is about to make preliminary tests of his new monoplane, which is now at M. Esnault-Lelterie's ground at Buc. It has a 4-bladed propeller in front, 2 m. 10 diameter, driven by a 35-H.P. R.E.P. motor.

M. René Gasnier, the well-known balloonist, has a monoplane under construction; it is driven by a 8-cylinder 40-H.P. Antoinette motor, and presents several novel features in design.

Among the host of experimenters are Comte de la Vaulx, Archdeacon, also Maurice Farman, who will attempt to emulate the exploits of his famous brother, and others too numerous to mention here.

One point worth noting with regard to aëroplane experiments has been the extraordinary immunity of aviators from fatal injuries after falls in which their machines have been partially or completely wrecked. This is, no doubt, because their flights have usually been restricted to a few metres above the ground, but, on the other hand, this practice probably causes more risk of mishaps. For instance, it is possible that Farman's accident on March 28th, 1908, would not have taken place if his machine had not been in such close proximity to the ground, and Delagrange, on the evening of May 2nd, 1908, when his aëroplane was carried out of his control into a crowd of spectators by the light breeze then blowing, might have been able to soar over their heads if he had been flying at a slightly increased elevation.

Although the aëroplane at present holds the field, there are several inventors—possibly half-a-dozen—who are devoting themselves to machines of the so-called "gyroplane" type (*i.e.*, aëroplanes with reduced fixed surface combined with a system of auxiliary sustaining helices inclined to the vertical), and also "hélicoptères" or direct lift machines, which

have no fixed surfaces, but are sustained and driven by propellers alone.

M. Louis Breguet, who is known to have made deeper researches into these systems than any other experimenter, but who has yet published little about the results obtained, has lately succeeded in making a machine with sustaining helices which rose into the air with its operator and motor in full order of march. He is strongly of opinion that sooner or later the aëroplane must be combined with auxiliary raising helices, and, as he has shown recently in an able paper on this subject, a gyroplane, under certain conditions, can leave the ground in a much shorter space than a simple aëroplane, the power used being identical in both cases.

No great success has so far been obtained in the case of a direct lift machine, but it is not impossible that an effective apparatus of this kind may be evolved in in the near future, and it might even have certain advantages as compared with the aëroplane, because it only requires a small area for experimental manœuvring. It is able to rise and alight in a restricted space, and it would be independent of the quality of ground surface, in addition to which the stability would probably be more easily perfected, though the power required would be greater, and there would be an increased risk of disaster in the event of the motor failing.

M. Paul Cornu's hélicoptère, which was completed at Lisieux in August, 1907, has since undergone repeated trials, and has raised itself with its operator from the ground on several occasions, though it failed to progress horizontally. This ingenious machine, which only weighs 260 kilos. with operator, consists of an open "V"-shaped framework 6 m. 20 long, built up of steel tubing, and mounted on four wheels. In the centre is the driver's seat, and in front of it the 24-H.P. Antoinette motor which drives, by means of a somewhat complicated belt system, the two large vertical propellers overhead (each is 6 m. in diameter with two blades of variable pitch); under the propellers in front and rear are two small vertical planes pivoted on a horizontal axis, and by their inclination and lateral displacement horizontal progression and steering direction are supposed to be obtained by the reaction of the air-currents from the sustaining helices.

M. Cornu has now decided to construct a new apparatus improved and modified from the experience gained, and in this new machine, which will be ready in a few months, he proposes to employ steel helices of small diameter and high speed of rotation.

M. Bertin, the motor cyclist, has also recently constructed a hélicoptère with the aid of his friend, M. Boulline, at Puteaux, though no tests have yet been made. This machine weighs 300 kilos. complete, and consists of a rigid framework of steel tubing containing a horizontal air-cooled 8-cylinder motor of 150-H.P., designed by M. Bertin, which drives through a disc clutch and bevel gears two metal twin-bladed vertical helices 2 m. 40 diameter at 1,200 r.p.m. In front is another gear-driven propeller, mounted on a shaft with universal joint, which can be utilised both for steering and propelling the apparatus. As to the future it is yet too early to forecast what is likely to become the eventual type of machine, but the problem of sustained flight with the aëroplane now seems to chiefly depend on the production of an engine which can run for long periods without failing, and which can be adequately cooled without material increase in weight. The motors at present used, taking the best-known types—Antoinette, R.E.P., and Renault—are now made of astonishing lightness per H.P., but still have various disadvantages for aëronautical work. They are difficult to set in motion, overheat after a few minutes' running, are rather complicated owing to the multiplication of cylinders and valves, etc., and do not develop their full rated power. Farman's 50-H.P. Antoinette motor probably does not give more than about 30-H.P. at propeller blades; also they are by no means economical in fuel consumption, which is a point which has not yet received the attention it deserves, and which must have due consideration in the case of long-sustained flights. The method of mixing is crude. In the Antoinette motor the carburettor is usually dispensed with, and the spirit pumped direct into the cylinders. These motors have not the flexibility of the steam engine, and the speed can only be varied within narrow limits—in fact, they

must run at a high speed (1,200-1,800 r.p.m.) to develop the maximum power. Consequently the propeller, if direct coupled, is of too small diameter for the best efficiency, and if a reduction gear is introduced, too large a proportion of the available power is lost in transmission.

After the design of the fixed surfaces, and next in importance to the motor, comes the question of the propeller, and though the various experimenters in France have discovered much that is new about the efficiency of the various shapes, and the best diameter, pitch, speed, etc., they have kept most of this information to themselves, and the published results are conflicting and even misleading. But this is not surprising when it is remembered that the present knowledge of even marine propellers is rudimentary and largely based on empirical formulæ. Much less is known about propellers working in air, and it has been found practically impossible—in the case of Farman's aëroplane, for instance—to determine with even approximate accuracy the thrust of, and the power expended on, the propeller at various speeds in actual flight.

In conclusion, judging from recent progress in France, it is safe to say that the next few years will set the seal on the victory which has already been won for the mechanical flying machine.

Mr. Cody: If I may mention a few words about that engine, I believe I have had as much experience with the engine as anybody in this part, and the one I used gave 51-H.P. at 1,475 revolutions, and at 1,200 it gave 46.8-H.P. So there is a mistake in the reference to this engine, distinctly, because all of the engines go from 51 to 53-H.P. before they let them leave the works, I believe. I have seen four or five tested in Paris, and I may say that they are very reliable, because the one I had in charge ran 3 hours and 40 minutes, giving about 38 to 42-H.P. by using the carburettor, and not the injection direct of the petrol, and, of course, the carburetter does not give the amount of power that the injection direct does, because, I suppose, it has to suck its charge from the jet in the carburettor, and there is a certain amount of power lost in the suction. When the petrol is put in direct the tube is open and there is no power lost.

A Member: Mr. Lloyd is talking about an air-cooled engine, and not one cooled with water.

Mr. Cody: He spoke of the Antoinette —the one used by Farman.

A Member: Is it a water cooler?

Mr. Cody: Yes. I have seen most all these machines in France, I think, except Farman's "Flying Fish." I know exactly what I am trying to get at; I am certain that the Antoinette firm made no air-cooled engine, or had not done when I knew them, and that was as late as three months ago. I may say also that my engine is the only one that has ever run the time it did at radiator cool, and that I felt the engine a dozen times during the run, and it was always cooler than fresh milk, cooler than blood heat as it went in through the pump to the engine—really too cool to get the results I should have got if I had let the water get a little hotter. I put in a large quantity. I had 26 quarts of water.

A Member: They couldn't have that with an aëroplane machine, could they?

Mr. Cody: I hope they will. I hope to have it myself, but it only means a question of time. The machine will lift it, if it will lift two men and its engine—it will lift 150 lbs. of water, the weight of a man. And Farman's machine did lift, or Delagrange's machine did lift, Mr. Farman and himself—so did Mr. Farman take his father on board. If, instead of taking his father, he would take water equivalent to the man's weight, he would get sufficient power out of the engine and fly all right. That is the only thing, I think, the French people are waiting for to get efficient radiators to the Antoinette engine, which weighs 218 lbs., in running order; but the same engine weighs 228 lbs. with the carburetter fitted, and the lightest air-cool engine of the same power weighs over 300 lbs. I am quite prepared to run the Antoinette for three hours with 300 lbs. weight, not to count the petrol.

A Member: 300 lbs?

Mr. Cody: 300 lbs.

Colonel Fullerton: 50-horse power.

Mr. Cody: Forty-seven, although the engine standing on the bench gives 51-horse power, but you cannot get it to give that constantly. That is why the racing cars on the Brooklands track, in my opinion, fail so often. If you have seen

the Brooklands racer—I have—and I have seen many races start with eight to 10 cars in them, and there is generally four or five cars drop out because there is no downhill, they never rest their engines —they are fully accelerated all the time, and the engines cannot stand it. But in a road race they go downhill at about 30-horse power and uphill they got at 100-horse power (with a big engine), and, consequently, they can keep their engine alive for a long time. But my experience with petrol engines has not been very long, it has been very much while I have been doing it, and I think that the only drawback to these light engines is that they start them off at their maximum horse-power and ask them to continue giving that maximum. There is no other condition where a petrol engine is asked to do that unless it is in a launch, and we all know how heavy the engine is in a launch to do any good. I hope I am interesting you. The point of the engine's efficiency is simply in the cooling, and as soon as we can get efficient radiators I hope we shall be able to fly all right; I hope to be able to get them. I am sure I will.

The PRESIDENT: We certainly have to thank the French for pioneering various enterprises, automobiles and aëronautics, and we are very glad indeed to have extracts of this interesting paper, and I hope we shall have an opportunity of reading it later on. We must go on, I am afraid, now to the next paper.

Owing to the absence of Mr. Wenham, his paper was read by the Hon. Secretary. The announcement by the Hon. Secretary that Mr. Wenham was 85 years of age and still took a great interest in the Society, of which he was one of the first members, was received with much applause.

Stability of Aëroplane Support for Flying Machines.

By F. H. WENHAM (Hon. Member of the Aëronautical Society of Great Britain).

The earliest attempts at flights by man have been by extended wings in imitation of those of bats or birds, all of which have ended with failure, or fatal accidents.

The bird-wing type for supporting a man and mechanism in air must extend at least 60 feet from end to end, and be very light and strong, for carrying the weight—an impracticable construction. All this is fully explained in a paper read by me in 1866 at the first meeting of the Aëronautical Society of Great Britain, of which I was the pioneer.

Perceiving that a single pair of far-extended wings was impossible for man flight, I evaded lateral extension by placing a system of five aëroplanes, or webs, above each other. The upper one slightly in advance. As all this is fully explained in the aforesaid paper I need not repeat it here. I only had the usual number of authors' copies, and as the present modern Aëronautical Society does not probably possess a copy, I herewith present one for reference.

Successful flights have recently been made in person by Wright Brothers in America and Farman in France. Both used only two superposed aëroplanes occupying a considerable extent of side room.

Lateral extension of surface involves a fertile source of danger by leverage from unbalanced side currents. If a machine with long wings performs a short turn during flight, either accidentally or intentionally, the velocity on the external radius is faster than the inner, and the extra side lift may cause the machine to turn over and disaster will be (and has been) the result.

The question of adequate lift in aërial machines has now been decided by means of supporting surfaces of textile fabric impelled by screw vanes. A screw working in air gives off such a feeble reaction that other means of propulsion should be sought for. Screw vanes acting vertically have not been successful, even for raising and conveying the mere weight of the mechanism required to drive them. In my essay of 1866 I occupy six pages relating to experiments with aërial screw vanes. The largest was six feet in diameter, with two vanes which could be altered for pitch in various experiments.

A screw acting as a blower for smelting furnaces for iron is never used. The blast from a fan-blower is far more energetic, in which the air is seized and emitted at a tangent, with a circum-

ferential pressure of over six ounces per square inch.

In a recent experiment I tried the following arrangement, as shown by the diagram Fig. X.: *a*, *a*, is an ordinary fan-blower with the casing open on one side at the centre and the circumference surrounded by a fixed rim dished at an angle of 60°.

The dotted lines represent the direction of the aërial current, which enters at the open side of the blower case, impinges against the closed back, and then diverges from the angle of 60, making the final exit in a direction parallel with the axis of the blower with a reacting force in the line of flight.

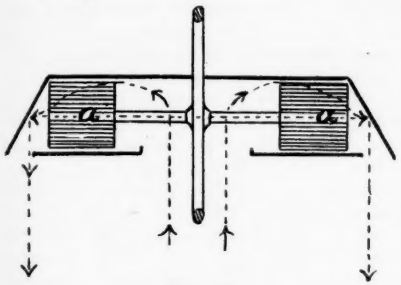


Fig. X.

The force of reaction was somewhat indecisive, as the current is twice deflected, but the effect was sufficient to warrant a trial of the arrangement on a larger scale.

Mr. Wenham, in the following letter, has touched upon an interesting point in connection with the question of longitudinal balance.

Birch Hill,
April 24th, 1908.

Dear Sir,—Many thanks for your letter of 21st. I am glad that you have decided that my brief paper is to be read before the Aëronautical Society of Great Britain (of which I was the parent in 1866). I then described my system of separated aëroplanes that have been successful with flight, so far as to place the possibility of man flight beyond doubt. Inventors adopt my ideas, but avoid mentioning my name. Before public use we have to consider the question of *safety*. Wright Brothers and Farman adopt only two aëroplanes extended above. I advocate *four*, as requiring only half the wing distance with corresponding safety from lateral oscillation.

But my main object in supplementing my paper with this letter is to record a defect that has not been noticed, but is detrimental to *longitudinal* stability, together with continual loss of propelling power.

The thrust from the propeller shaft should be in the centre of the pressure—that is, if the machine were placed to meet the wind, the force of this should be balanced by the pressure above and below this point, otherwise there would be a skew action like a horse drawing outside the shaft of a vehicle instead of a midway straight pull. The propeller can be driven by a belt so that the spindle can be placed in any desirable position to secure a balanced thrust.

For a single aëroplane of large surface the worked-up exhausted air should be got rid of by openings in the web. I have found these orifices to be an advantage, and this is demonstrated by me in a paper in the *Proceedings of the International Conference on Aërial Navigation, Chicago, 1893.* [If this book is not in the library of the Society I will present my copy.]

I enclose a photo of my appearance in 1866, as I cannot now attend Society meetings, being somewhat deaf, and am at the close of my 85th year.

As this letter is addressed to you, I leave it to your discretion to read it before the Society as supplementary to my last. Flight will now become general if safety in construction and use can be secured.

Yours faithfully,
F. H. Wenham.

The President: The author of the next paper not being present, the Hon. Secretary will read it.

Flying Ships of the Future.

By Edgar E. Wilson.

Within the limits of the present article it would be impracticable to deal adequately with exhaustive constructional details, or, in fact, many points bearing particularly upon the gist of this subject. Suffice it, then, to briefly refer to those facts by which the fundamental laws upon which is evolved the future complex and impressive airship of the near future is based, the lessons of Nature containing those laws, and which, in these modern days, are certainly insufficiently studied, and how man can reproduce these self-same teachings by his methods culminating in the long-cherished, but by no means apocryphal and abortive, *subjugation* of the wide realms of the air.

The flying and soaring of all natural volant creatures is simply explained on well-known mechanical principles, and

the majestic air-craft of the future will, in short, embody those principles *inter alia* by the ingenuity of man. The ulterior and chief object of this lecture is an ambitious one; indeed, I may add the objects are several. It will (1) explain concisely and succinctly the fundamental laws of flight as shown and explained by Dr. Pettigrew, who has shown the true pioneer path to success; (2) compare these trenchant lessons of Nature to present types of machines; (3) seek to elucidate the promise of useful aid in these present experimentalists and its ultimate adaptation to more perfected machines; (4) expound the principles upon which the progress of the flying problem on the one hand and the laws demonstrated by Nature on the other evolves a practical dynamic airship; (5) seek to divert into sound channels the prevalent wave or trend toward the illusive, incomplete, and dangerous so-called "aëroplane" (which has no real analogue in Nature), as so ardently yet illogically favoured by the majority of aëronautical students; (6) and lastly, to enunciate one or two fundamental and far-reaching laws in the design and perfection of true aërodynamical flying ships of the future, their true capabilities, distinction, and superior qualities wherein to merit the proud emulation of "the way of an eagle in the air."

Perhaps I may be pardoned for reviving and dwelling upon the lessons of Nature, but it is necessary in order to convey the points advocated to do so, in addition to which it will serve to teach the beginner in aviation the groundwork of this broad science, since, to the advanced philosophical enquirer, it is all too apparent that they begin at the wrong portion of the subject, repeat previous failure after failure, and finish at length in disaster or incomplete results.

The earliest flying creature known to science was the great extinct pterodactyle, of the order *Pterosauria*. This truly wondrous bird-reptile forms a striking testimony to the feasibility of flight by large wings, specimens having been discovered in the fossilised state in the cretaceous rocks in England with wings 25 feet tip to tip, and there can be no doubt that they flew. From these huge antediluvian pterodactyles (Greek: wing-fingered) we pass to the order of *Diptera*, or "two-winged," as the wasp, house-fly, or bluebottle, *Coleoptera*, or beetles, *Hymenoptera*, or butterflies, *Odonota*, as the dragon-flies, *Cheiroptera*, or bats, to the perfection of flight, the birds.

Varied in structure and contour, although these natural flying machines may be, it is significant that all fly on one and the same principle—the screw. And innumerable in variety, some being falcated or scythe-like, some oblong, others rounded or circular; whilst others are again linear or lanceolate, it is noteworthy that they *can* fly, thus proving that the travelling surfaces of the human-built flying machine need not be restricted to one particular design, but the main principles and agencies underlying both must not be transgressed from, and which are clearly set forth as this lecture proceeds. Note, therefore, there must be no escaping or divergence from natural laws. *A thorough knowledge alone will enable us to design fundamentally and construct a true flying airship.*

Therefore without unduly enlarging upon these varieties of formation, we know by Pettigrew's life-work that the bird's wings are of helicoidal curvature throughout, with semi-rigid margins anteriorly and flexible posteriorly, the whole wing graduating in form, the thickest commencing at the shoulder and tapering to a fine plastic point at the tip, which enables the wing to be naturally and automatically stable when struck by oppositionary winds or those of a vertical tendency. It is, however, the following points that the writer wishes to enlarge upon, as this is the key to the whole problem of successful flight, and the true dogma and distinguishing feature whereby the groundwork of artificial flight *must* be encompassed.

All wings, with the exception, of course, of the order *Hymenoptera*, or butterflies, in addition to being structurally and functionally powerful propellers, elevators, and sustainers of remarkable efficacy when in forward translation in helicopteral flight, have their travelling surfaces or "sail-area" reduced to apparently inefficient dimensions, and one would imagine wholly incapable of flight for a short period, to say nothing of lengthened duration. Quite so. To accomplish this seemingly impossible feat, Nature increases the "sail-

area" by rapid motion, well knowing that when driven at high speed they augment the active area and practically convert the spaces through which they travel *into solid bases of support*, and as the wings or screws travel at much higher velocities than the air-currents they are in, they are superior to and control them by superior power (residing in the powerful pectoral thoracic muscles), greater speed, perfected travelling surfaces designed to satisfy the resiliency of the air, and the inertia of the mass of the flying animal. Slight though this last may be, there is no contradicting their ability to fly and soar upon even adventitious currents, demonstrating the truth of the assertion that "the whole of the wing is utilised to consummate the triple function of elevating, propelling, and sustaining. Figs. XI., XII., and XIII., will illustrate clearly this principle of augmenting the "sail-area" by a partial rotational motion, the last showing how man reproduces this law by means of the rotary screw propeller. Fig. XIV. illustrates the illogical "reproduction" of this law in the Farman-Delagrange machine, showing the immense preponderance of passive or useless dead "sail-area," and the ridiculously inadequate proportion of active or useful area in the tiny screw of two metres diameter. The dead "sail-area" is 560 sq. feet., against some 30 sq. ft. only of the screw when in motion. Hence, notwithstanding the great superiority of the inertia of the mass over natural flying machines, yielding, in fact, a weight of 1,100 lbs. against the 38 lbs. of the heaviest bird, the great bustard (*Otis tarda*) in conjunction with immense power (50-H.P.), this machine, so far from attacking and subjugating the whirls, waves, and eddies of even moderate winds by superior volition, power, and properly-fashioned surfaces which yield both natural and artificial stability, can venture only aloft a few feet off *terra firma* in a virtual calm zone, and, instead of eliciting an upward and responsive recoil of the predominant active surfaces as it should be, the tiny screw barely suffices to keep the machine aloft, whilst the operator is working in Herculean efforts to endeavour to maintain equilibrium, which is truly impossible when sudden gusts are encountered, and particularly those of a vertical tendency, and all aëroplanes are similar and susceptible.

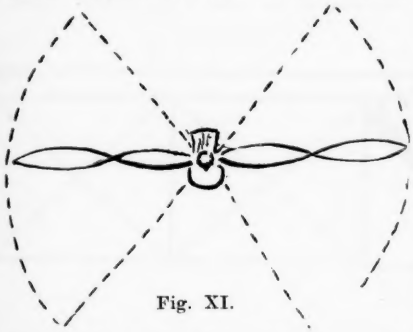


Fig. XI.

Fig. XII.

In short, the most practicable and sensible contrivances likely to solve the problem are those which are designed and constructed to take advantage of natural laws, to imitate the bird, "that admirable type of aërial locomotion" according to Marey, as indeed it is, and which are:

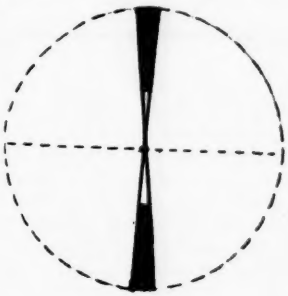


Fig. XIII.

(*a*) *Hélicoptères*, or "screw-flyers," which are simply screws with vertical axis, acting in co-operation with suitable fixed aëro-curves or aëro-surfaces of bird-like concavo-convex design. These surfaces need not be vulvular. Propulsion should be effected by twin propellers.

(*b*) *Orthoptères*, or aviform mechanically-beaten wings, relying solely upon this design for propulsion, elevation, and sustentation.

Hence the problem resolves itself into a study of the bird and all winged creatures, the atmosphere, the hélicoptère, and orthopteric machine respectively, and their co-relation one to another. At this juncture it may prove advisable to enunciate the fundamental laws necessary to encompass true aviation, endorsing each in detail by experiments already well acknowledged and beyond reproach from controversialists.

Fundamental Laws.

(1) The aëroplane, as so distinguished by reason of its large, immoderate, inert, and passive surfaces, whether they be of the superposed "double-decked" type or monoplane single surface, either impelled from behind or towed by a tractor-screw before, should be now rendered utterly obsolete, their employment arbitrarily eschewed, and the principle relegated into one of limited possibilities. It has no true natural stability, is unsafe when flying transversely across the wind or when encountering currents of any strength or of vertical propensities. As a scientific aërodynamical machine it is a failure for these reasons, and is only suitable under favourable atmospheric conditions to win a prize when travelling at low altitudes. For war purposes it is utterly worthless.

(2) By a combination of natural and artificial stability attained by (*a*) multiplicity of rotational surfaces or screws in the hélicoptère type, the vibratory wings acting in co-operation with them to be of moderate alar extent, and which may, in fair winds, be fixed, the centres of pressure and gravity mutually coincident (this being universally known), and the auxiliary surfaces so utilised should be capable of flexure and folding closely against the sides of the aëronef as in Nature to present virtually undue head resistance.

(3) It is imperative that all wing-surfaces, whether in an advanced homogeneously designed aëronef with horizontal and vertical helices, shall be closely reproductive of birds' wings in design, hyperbolically arched transversely, sinuous, and of concavo-convexity in section, and must be flexible posteriorly and most particularly at the tip. This last confers natural stability in tumultuous winds, as vertical currents strike the wing its resiliency enables it to yield and spring back to the normal position instantaneously. The wing-surface, more-

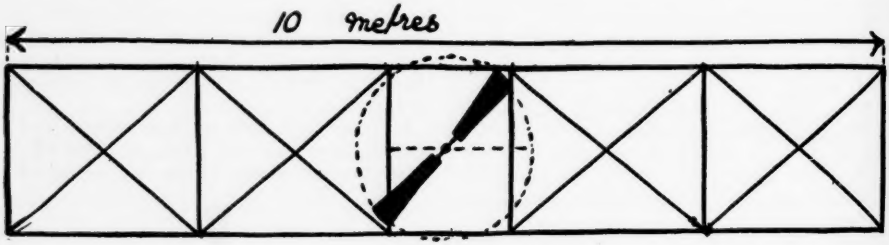


Fig. XIV.

over, need be of membraneous construction, and should copy the design of the shaft or quill, the fulness of the penna and semi-rigidity of the anterior margin of a primary feather for simplicity of construction in preference to the complicated shape of the homologous wing.

(4) The wing-surfaces, screws, rudders, and, in short, all active or passive sustaining or steering area, should be constructed as lightly consistent with strength as will be found commensurate with safety. All wings, tails, or travelling surfaces in Nature are, fundamentally, exceedingly light, though the body is heavy and the weight concentrated. Hence, the ratio will increase only one-fourth instead of cubed by this law of light construction.

(5) In the hélicoptère principle additional systems of auxiliary wing-surfaces *must be employed*, on the score of safety in the event of equilibrium being lost

through stoppage of machinery, breakage of one or more screws, or other cause.

(6) These wing-surfaces should (*a*) be capable of being utilised under the conditions of law 5 as *independent* beating wings to prolong and continue the flight if desirable; (*b*) may be employed in normal flight simply as additional "sail-area" in moderate winds by a fixed, immovable position; (*c*) the proportion of the total "sail-area" should equal approximately as possible the weight of complete machine at the ratio of 2 lbs. per sq. ft., which, in the light of Farman's experiments, have been found efficient to alight safely; (*d*) for an advanced type of homogeneous machine on the compound wing and screw type two independent engines should be employed, one for work, the other as reserve in extremity.

(7) Twin propellers, if used, are best for forward motion of intermediate size and diameter, and must be placed at the rear of the aëronef, actuated, if convenient, by a smaller engine than required for the ascensional screws, a vertical rudder affixed in the centre of propellers as in marine practice. The rudder, so placed for horizontal steering, would conduce to stability on a transverse plane by artificial aid.

(8) The propellers should preferably be constructed on the Kress or Voght type to ensure by their flexible posterior margins variable pitch to accommodate them to the speed driven. Autorotation by this system will be negligible when the wind is blowing at right angles to the blades as in the marine helix, *i.e.*, when the flying ship is either stationary or in hovering flight. The propellers of Nature are, of course, in the fore part of the body. The reason that the human machine should place the aëronef's propellers as enunciated is that the ascensional screws are both propellers and elevators combined in that adopted by the writer, hence very slight propulsive aid from the twin propellers will be requisite in practice.

(9) All elevating helices and wing-surfaces in either aëronefs or aviform wing machines should be "stepped," whilst in the former the component auxiliary primary surfaces should coincide with the angle of incidence of the helices, and must be high above them to satisfy the need to work on fresh, undisturbed air; the ascensional screws to be on a level partially with the car.

(10) The construction and design of the aëronef should closely approximate to the fast flying bird type such as the swift (*Cypselus apus*), albatross (*Diomedea exulans*), frigate-bird (*Tachypetus aquila*), sparrow-hawk (*Nisus communis*), swallow (*Hirundo rustica*), and similar examples; the greatest width of the hull in the forward part and tapering to a more or less flattened section at the rear. In the orthopteric machines this reproduction of the bird's body can be followed precisely. In the structural emulation of the aëronef type it will be found more practicable to approximate the aquatic or machine vessel, since the stream lines of air will be divided into component waves, reducing head resistance to a minimum. Moreover, it must not be overlooked that the combined thrusts of the ascensional and propulsive screws will be enormous, literally forging the flying ship with the potential aid of gravitational energy and the immense inertia of the mass of the dynamic airship through all resistances tending to deflect the aëronef from its course, and the vertical elongation of the anterior margin of the hull, so far from proving undue "drift," will more than counteract it by the shape facilitating lateral control on the fin keel principle.

(11) The highest fundamental law in the case of the hélicoptère or ascensional screw type is the position of the main weight in forward translation, and accounts in all predecessor machines for their failure hitherto to secure propulsion through the erroneous position of the centre of gravity. Paucton, in 1768, Meerwin, Launoy Bienvenu, Deghen, Ottoris Sarti, Dubochet, Henson, Cossus, Bright, Pénaud, Camille Vert, Pline, Bréant, Nadar, Ponton d'Amécourt, De la Laudelle, Forlanini, Dandrieux, Castel, Phillips, Giffard, Lenoir, Renard, Léger, Santos-Dumont, Kress, Bertin, Cornu, Bréquet and Richet, one and all have the centre of gravity erroneously located.

(12) The final law has reference to the orthopteric type of dynamic flyer, and additionally propounds the inference that clearly failure to encompass flight in imitation of the bird in accordance with the figure of 8 waved line of progression when the wings are beaten in a vertical

direction *simultaneously* is the great complexity of this motion, one partisan school assuming that the reciprocal periodicity of wing beats in the up and down strokes should be irregular in duration, whilst the opposite school with equal confidence assure us that the period is equal, and no matter if the beats be of short or long duration and the amplitude either, forward motion must result when the pinions are actuated. Personally, I am inclined to favour this view also, on the basis of experiment and judgment, in that since reciprocal wing beats are portions of a circular disc or path (see Figs. XI. and XII.) it follows that forward component is the result, and Marcy's views to the discrepancy by sphyomorgraphic records are due to the elasticity of the pinion on the one hand, and the superior contraction of the pectoral depressor muscles antagonising the inferior qualities of the elevator muscles on the other, in conjunction with the concavo-convex shape. I would furthermore condemn as unnecessary the servile copy of the whole wing embodied in the Frost, Hutchinson, and D' Esterre machine, splendid though their results have been in securing a lift of 170 lbs. with 1-H.P. in one single down stroke, if this be authentic. This machine, moreover, contains, with Major Moore's flying fox and many others, the fatal and insuperable inability to prevent loss of stability when at the lowest point of the down-stroke, should power be suddenly lost. Since, therefore, this principle of reciprocal flight rejects it for practical work, we must seek a compromise in the system of Jobert, Holland, and McKee (the latter is here to-night), in that we have designated the " Roller " principle. This principle, also advanced by Rénard, unquestionably explains the secret of the hitherto imperfectly comprehended soaring flight of the condor (*Sarcoramphus gryphus*), buzzard (*Buteo vulgaris*), albatross (*Diomedea exulano*), eagle (*Aquila chrysœtus*), and the rest of the gliding birds. Briefly, on the albatross, swift, etc., encountering powerful cross-currents in conjunction with their swift flight; these vertical currents obviously have a tendency to deflect the course of the flight, hence the bird swings or rolls transversely and so transfers its wings into twin propellers, the feathering action also yielding a sinuous form of the wing (Fig. XV.). Consequently if we apply four wings in tandem á la Langley, Brown, etc., superposed or monoplanes, and impart a converse motion to the wings, the result is, we have a simple *reproduction* of Nature without any danger of disaster, whatever the angle of the amplitude be arrested at. Here, therefore, is a still further triumph over Nature. A bird, once shot, the equilibrium is gone, and the bird falls headlong. In our " Roller " type, were

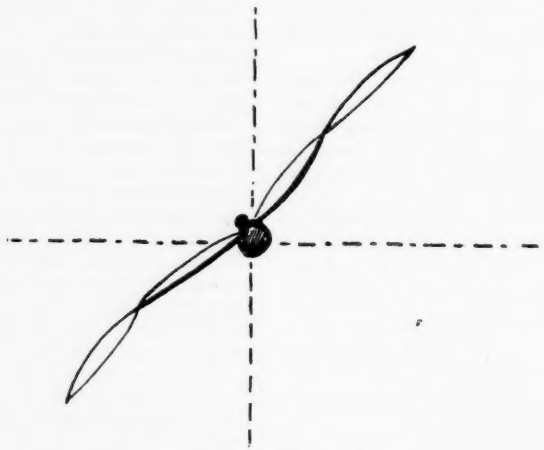


Fig. XV.

the engine to stop, the equilibrium is maintained, whilst diminution of the parachute area is impossible with the springs beneath representative of the pectoral cord. The second type of practical flying ships of the future, there is no doubt, must be on this principle of aviation (Fig. XVI.).

SUPPLEMENTARY REMARKS.

From the researches and experiments of physiological enquirers in the aëronautic engineering world comprising French, German, American, Italian, British, etc., the writer sincerely trusts that it is now clear, without bias nor prejudice, that a remarkable analogy exists in the co-relation of the laws of Nature and their evolution to those types of flying ships of the future, which may be appropriately termed the "Aëronef" and the "Roller" principles. The screw principle, form and flexibility of the bird's wings is unquestionably the distinguishing feature towards artificial flight, and the innumerable varieties of form in Nature's screws does not contradict the fact that all fly on precisely the same laws, and flight by mechanics is, therefore, the product of superior inertia, volition, power, and properly constructed flying surfaces (one primary feather, indeed, being morphologically or functionally and structurally equivalent to the whole wing), without which mechanical flight will never subjugate the conflicting waves of atmospherical space.

In the designs herewith shown (Figs. XVI. and XVII) the writer personally favours the aëronef type, in that the ship is susceptible of rising vertically upward or descending within a confined space, will be capable of hovering above one spot, can sustain itself aloft with its spinning helices at high velocities, rotating irresistibly in strong, tumultuous winds, whilst the fixed wing-surfaces can be flexed, and has the additional claim for superiority in the simple yet efficient mechanical motion of the screw, whereupon it

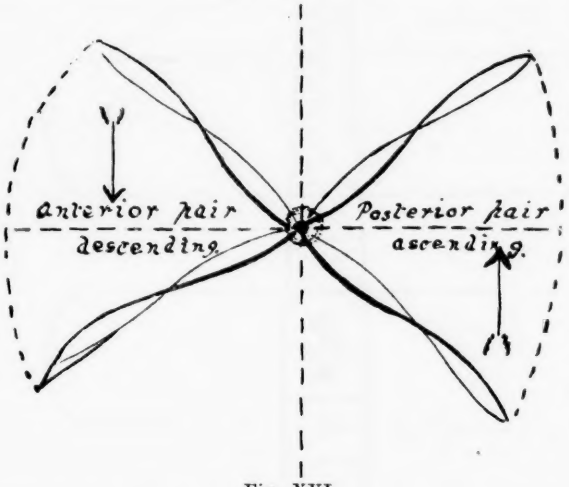


Fig. XVI.

may be found disadvantageous in the wing type in powerful winds by the great expanse of superficial area exposed, flexure, of course, resulting in a fall. With regard to artificial aids by means of automatically restoring equilibrium by movable centre of gravity to retain coincidence with centre of pressure due to changes of incidence, or gyrostats, interlocking devices by pendulum, etc., the length of this lecture prohibits an exhaustive description, which must be left for future lectures describing progress with a pioneer machine.

To succinctly summarise the proposed aëronef herewith portrayed under construction by the writer as a pioneer craft

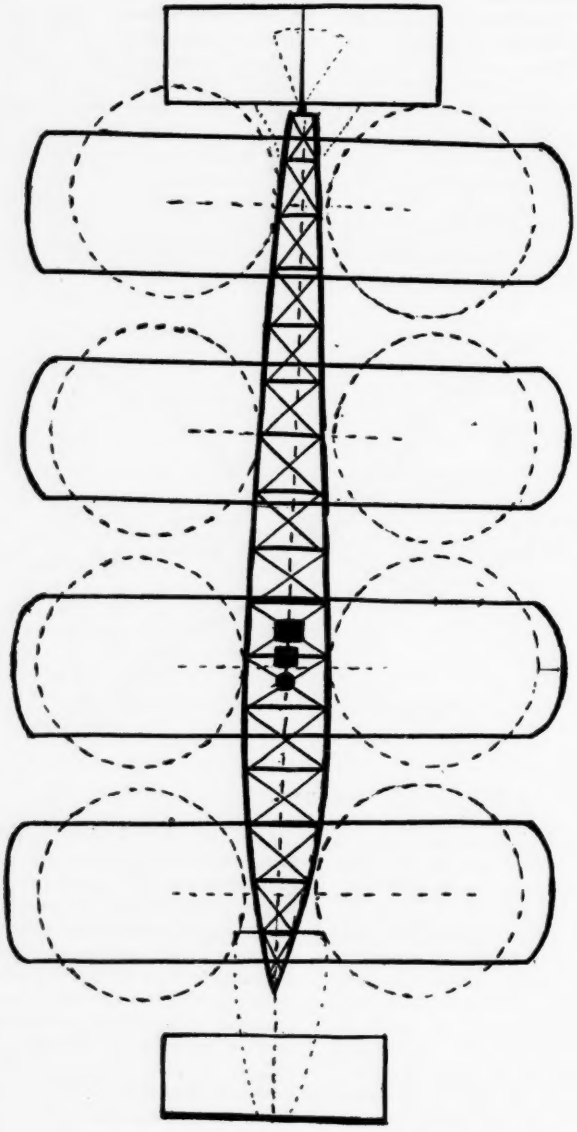


Fig. XVII.

embodying the whole of the foregoing laws, the machine is 32 ft. long by 20 ft., with eight ascensional screws as depicted, is capable of flight solely by these alone, but has the additional practical advantage of the wing-surfaces flexed above, and which are truly "automatic parachutes." Funds render the rapid completion slow; indeed, the writer would point out that were he a Henri Deutsch, a Santos-Dumont, or a Government official, he would certainly build a true liner of the clouds over 100 ft. long, 72 screws, and 250-H.P., which would present a magnificent spectacle of a glittering magnalium hull surmounted by swiftly-rotating helices irresistibly forging its path through the whirls and eddies of atmospherical space. Such a veritable example of *multum-in-parvo* would not exceed 5,000-lb. load, yielding 2,000 lbs. for complete machine and 1,500 lbs. for light engines, or 6 lbs. per H.P., leaving 1,500 lbs. for fuel and aëronauts. That the thrust of the helices at the ratio of 20 lbs. per H.P. is feasible will readily be seen by the thrusts of various experiment lists subjoined.

NAME.	No. of Screws	Diam. in feet.	Thrust in lbs.	Total H.P.	lbs. per H.P.
Giffard	1	8	165	6	27·5
Dahstrom and Lehman ..	1	8½	55	1½	36·7
	1	5	45	1	45
Moy	2	12	120	3	40
Renard	1	23	432	9	48
Maxim	2	17′ 10″	2,000	363	5·3
Kress	2	12	82(?)	1	82
Léger	2	20	240	6	40
Walker	1	30	1,250(?)	50	25
Santos Dumont..	2	20	400	28	17·5
,,	1	20	198	9	22
,,	1	6½	332	50	6·6
Bréquet	32	26½	1,190	40	29·2
Cornu	2	19·68	853	24	35
Rankin Kennedy	2	5	72	3	24
Pickering ..	1	12	48	1	48
,, ..	1	20	430	20	21·5
Farman ..	1	6½	375	50	7·4
Sidney H. Hollands ..	1	6½	26½	1	26½

By comparing the thrusts, particularly Maxim and Bréquet, it will be seen that the ratio of lift increases in proportion with additional area, whether passive or active.

A loss by friction of 30 per cent. is more than compensated by forward motion, the Copenhagen experiments and smaller ones by the writer having demonstrated that a wind blowing transversely across the blades increases the "lift," and augments it 75 per cent. With regard to stoppage of one or more screws or portion of machinery, it has been demonstrated that the remainder would continue working, and the fall is transferred in a series of wide curves in the form of a conic section whose base is upward, allowing ample time to operate the automatic parachutes which have opened within a second in a fall of 50 ft., in a vertical descent with experiments with specially designed parachutes made by the writer. That the flying ship of the future is unquestionably upon the lines of the aëronef and the roller principles it has been the effort of the writer to attain. That the winged roller system is superior to other wing types none will dispute. The Weiss model will repeat in gliding the drawbacks of the aëroplane on a large scale and is inevitable. In reality, this system is a copy of the simple experiments with planes given by Marey in "Animal Mechanism," and though this upward curve is seen in the poster margin of the rook (*Corvus frugilegus*) and magnified in the carrion crow (*C. corone*) and grey crow (*C. cornix*), it is significant that they vibrate these wings and rejoice in the possession of a rear tail of ample proportions. Yes, the future of aërial locomotion belongs to the true flying ships, and to which the subjugation of the blue waves of the atmosphere will assuredly fall.

The PRESIDENT: I think it only remains now to thank the authors for the interesting papers we have had, and I must thank Colonel Fullerton very much for reading the papers so excellently. (Applause.) Thanking you for your kind attention here this evening, with these few words I close the meeting.

Major BADEN-POWELL: May I interrupt you, Mr. President, one moment? Ladies and Gentlemen, I think that we ought to accord a vote of thanks to the President, who has taken the chair to-night, and though I have nothing much to say on this occasion, still we have to remember that this is the first occasion—I think I am right—on which the new President has taken the chair. And, therefore, it is a very opportune one to give him a good vote of thanks. I think that it may

be of interest for me to mention that we have here to-night several very distinguished foreigners, come over to represent their various countries. There is Mr. Hergezell, who you all know by name, and Colonel Moedebeck, whose pocket-book we all know so well. I know they have been very interested in the proceedings, even though they say they have not been able to understand all that was going on. However, I will only ask you to accord a vote of thanks to the President for presiding to-night. (Applause.)

Colonel TROLLOPE: I beg to second the vote of thanks and couple with it the name of Major Baden-Powell.

The PRESIDENT: Major Baden-Powell, Colonel Trollope, Ladies and Gentlemen, I am extremely obliged for the honour and confidence you have placed in me.

The following paper was accidentally delayed in transmission, otherwise it would have been read at the meeting:

On the Conditions of Equality of Statical Stability, between the Dirigibles "Patrie" and "Zeppelin."

By CAPT. GUIDO CASTAGNERIS.

In a paper published in the Journal of the Aëronautical Society of Italy, p. 267 (1906), I explained some interesting points regarding certain constructional technical advantages, dynamic and economic, special to the systems of dirigibles, which have a cylindrical form of great length, a very much reduced midship section, and a minimum distance between the point of action of the ascensional force and the axis of the car, of which the "Zeppelin" shows, in practice, a very successful example.

Mr. Laboccetta, in his paper, in the same Journal, page 2, 1907, when comparing certain types of dirigibles, pointed out the influence of the co-efficients of resistance to forward movement, the value of extended forms, the importance of fair shapes and lifting power, and showed the advantages of the extended shape in certain cases. The "Revue du Genie Militaire," October, 1907, also alluded to the points which I considered in the Journal of the S.A.I. (1906), but like nearly all the other technical experts, omitted to draw attention to the very interesting question raised by the "Zeppelin" consequent on the smallness of the distance between the point of action of its ascensional force and the axis of its car, compared with its great length. I return, therefore, to this question, as it is daily becoming of greater importance, owing to the efforts made by the designers of dirigibles to arrive at good practical forms, smaller resisting force, greater economy of motive power, better stability arrangements, and higher efficiency generally from the commercial point of view. The idea of this paper is, therefore, to draw attention to the conditions necessary for comparing the values of the static stability of the two systems, having maximum and minimum distance between the centre of gravity and point of application of the ascensional force, as their chief feature.

The technical subjects, which have almost for the same reasons been the object of discussion among naval architects, will serve us as guides and sources of instruction for the similar aëronautical questions.

I repeat that it will only be by a truly impartial and careful examination of the different problems bearing on all the aëronautical systems and the questions of working, transport, etc., that public interest will be aroused, and rapid and wonderful progress made.

The two types of dirigibles to be compared have as chief characteristic the different distribution of the load, relatively to the longitudinal axis.

In the dirigibles of the type "Patrie" the load is almost entirely concentrated in a single car placed immediately below the midship section.

In the "Zeppelin" the load is divided between two cars, placed symetrically, relatively to the mean cross section.

To the type "Patrie" belongs the "Ville de Paris," the "De la Vaulx," the "Parseval," the "Gross-Basenach," and the "Nulli Secundus," the three last-named having a cylindrical instead of a spindle-shaped form. In the type "Patrie" one is obliged to concentrate the load in a single mass, not only on account of its small capacity, limited

space for mechanism, safety, etc., but also because this course is necessary to ensure the chief and essential point, without

The "Parseval," "De la Vaulx," and "Gross-Basenach," have their propellers fixed between the car and the envelope,

Fig. 1.—"Zeppelin III."

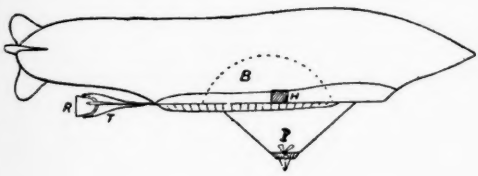


Fig. 2.—"Patrie."

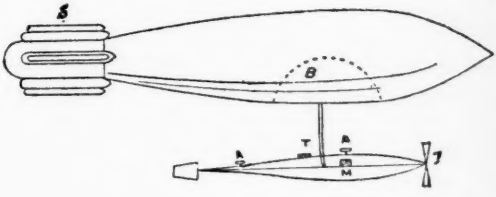


Fig. 3.—"Ville de Paris."

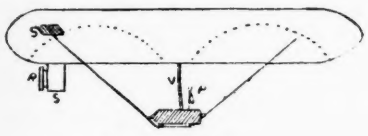


Fig. 4 — Von Parseval.

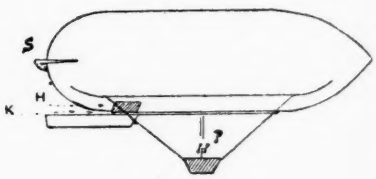


Fig. 5.—"Gross."

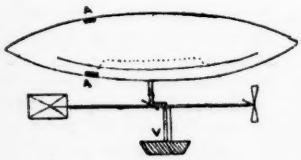


Fig. 6.—"de La Vaulx."

Fig. XVIII.

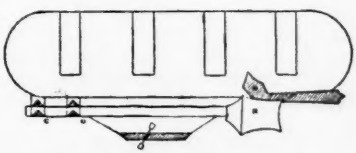


Fig 7. British Government Airship.

which the whole system is dangerous, viz.: a powerful pendulum-like action of the load, tending to always restore it to a position vertically below the midship section.

an unsatisfactory arrangement from the safety point of view.

The "Zeppelin," on the contrary, is unique of its kind. Its great length necessitates a special distribution of the

load, and this distribution rather makes one think that all idea of obtaining a natural pendulum-like motion for regulating the oscillating and pitching motions of the airship has been abandoned.

The first distribution of the load was made without any very exact knowledge of the requirements of the case. Later, in 1900, a moveable weight of 100 kilg. was hung 25-30m. below the cars, to assist in balancing the machine, but, subsequently, this arrangement was altered, and a rolling carriage (150 kilg.) running on a rail fixed in the gallery connecting the two cars substituted.

for the transportation of heavy weights (as in the case of Atlantic liners), it will be necessary to use propellers, coupled in pairs, of dimensions suited to the rotational speed of the motors, and when the length of these dirigibles is taken into consideration it is clear that all attempts at concentrating the load as is done in the "Patrie" must be given up.

The arrangements for the distribution of the loads in the different parts of the system, the necessity for avoiding lines of suspension of great length and angular divergence, the large diameters and heavy weights, and the importance of cer-

fig 2

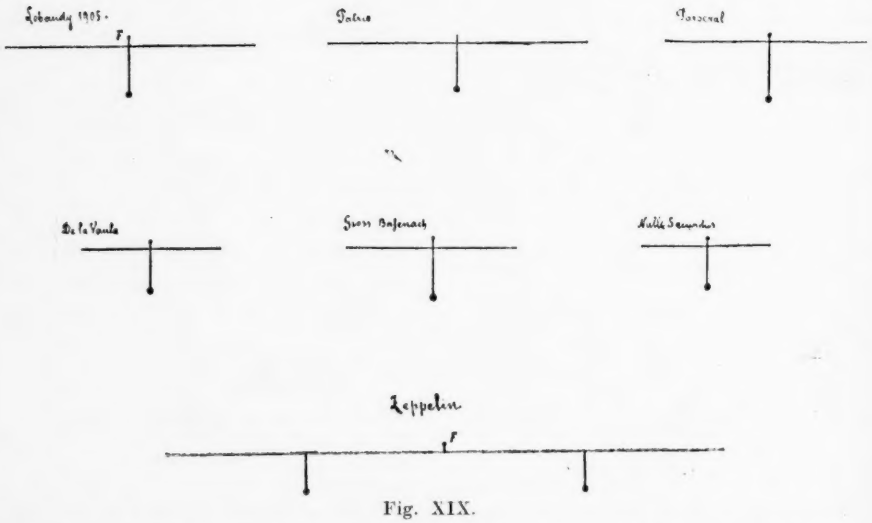


Fig. XIX.

Finally, the moving weights were done away with, and the system of "empennagement" invented by the late Colonel Renaud, of the French Engineers, adopted. This, with the balancing planes of the "Patrie" type, ensures for the "Zeppelin" a very satisfactory statical and dynamical stability.

The splendid trip made in September, 1907, lasting seven hours without landing, covering a distance of nearly 340 kilm. in a closed circuit, with departure and return in one day, gave an indisputable demonstration of the aëronautical qualities of this airship and of its stability.

Owing to the great size now demanded

tain arrangements for ensuring a rigid connection between the car and the envelope, impose a particular method of distributing the fixed loads and the use of dynamic balancing planes so as to ensure constant equilibrium during the small and unavoidable displacements caused by the variations of the moveable loads. Further, the variable loads, such as the ballast, petrol, cooling water for the motors, lubricating oils, etc., must be placed in a central reservoir (with small auxiliary reservoirs) in such a manner that the reduction in their weight does not alter the trim of the airship.

The "Zeppelin" is a good example of

the best distribution of the fixed loads as, notwithstanding its great length, it only requires balancing and "empennagement" planes of small dimensions. The results of the "Zeppelin" are, therefore, very important and instructive, and show that the popular idea that there should be a considerable distance between the axis of the car and the point of action of the ascensional force is quite erroneous.

mental tests alone that precise and definite data can be obtained.

In Fig. XVIII. are given diagrams of the different types of dirigibles which up to now have given the best and most useful results. Fig. XIX. and the table given below, show at a glance the distances between the point of application of the ascensional force and the axis of the car in the dirigibles mentioned.

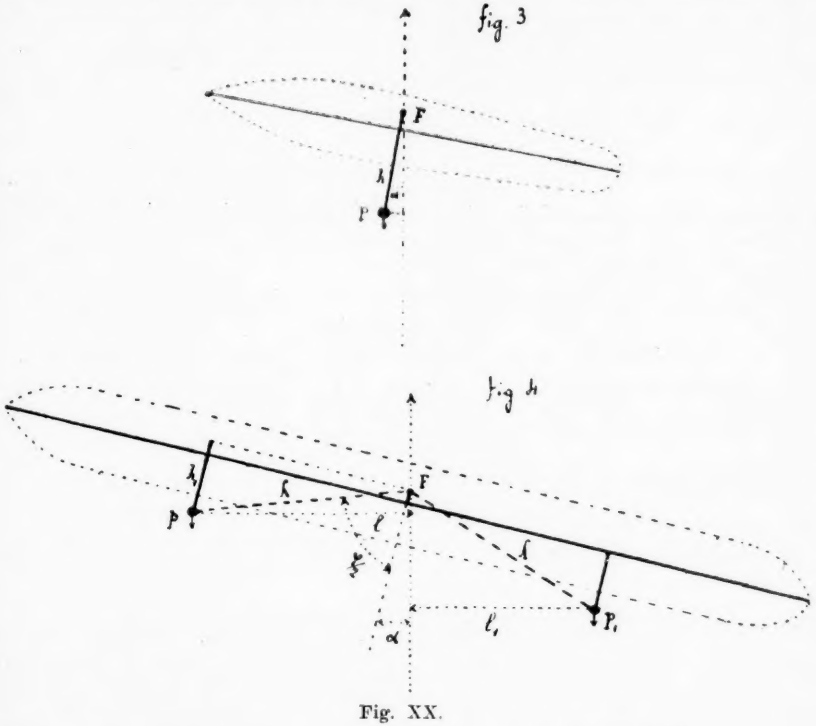


Fig. XX.

There is also nothing to prevent the investigation of the relations which should exist between the principal data of comparison of the statical stability qualities of the systems "Patrie" and "Zeppelin," and, as regards the latter airship, all the cases special to its load distribution can be equally well examined.

This examination is the more desirable because Count Zeppelin has always withheld information about the stability of his system. It is to be hoped, however, that he will now give to the world the results of his observations, as it is from experi-

TABLE I.

Name.	Length. Metres.	Distance between the point of application of the Ascensional Force and the axis of the car. Metres.	Ratio between Cols. 2 & 3.
France	50·42	9·80	5·14
Lebaudy	58·00	10·70	5·42
Patrie	**60 00**	10·90	**5·52**
Parseval	48·00	14·20	3·39
De la Vaulx	32·50	10·10	3·22
Gross-Basenach	40·00	11·50	3·49
Nulli Secundus	30·00	10·10	2·97
Zeppelin	**128·00**	8·70	**14·70**

In Fig. XIX. the point F on each diagram represents the approximate position of the point of action of the total ascensional force of the system. This point is, consequently, the centre of rotation of the oscillatory and pitching movements of the dirigible.

One sees from the figures that "The France," the "Lebaudy," and the "Patrie" have a ratio of distance between point of application of the ascensional force and length of dirigible greater than $\frac{1}{5}$; the "Parseval," "De la Vaulx," and "Gross-Basenach," a ratio greater than $\frac{1}{8}$; the "Nulli Secundus" of $\frac{1}{2\,97}$; and the "Zeppelin" of $\frac{1}{14{\cdot}70}$

From Figs. XIX., XX., and the following tables one sees the general relations between the dirigibles "Patrie" and "Zeppelin," and the different elements, moment of inertia, and periodic times.

TABLE II.

MOMENT OF INERTIA J.

h = distance between F and axis of car.
h_1 = " " "Zeppelin."
λ = radius of gyration of the masses p p_1 "Zeppelin."
$p = p_1$ = weights of the cars "Zeppelin."
P = weight of the car "Patrie."
$P = p + p_1 = 2p$,
then

Type "Patrie."	Type "Zeppelin."
$J = Ph^2$	$J_1 = 2p\lambda^2$

if

$$\lambda = \frac{h_1}{\cos\frac{\phi}{2}} \qquad h_1 = \frac{h}{n}$$

$$J_1 = P\left\{\frac{h}{n\cos\frac{\phi}{2}}\right\}^2$$

The moments of inertia will be equal in the two systems with respect to their cars in all cases where

$$n^2\cos^2\frac{\phi}{2} = 1$$

that is to say, for example, when

$$\left.\begin{array}{ll} n^2 = 1 & \cos^2\frac{\phi}{2} = 1 \\ n^2 = 2 & \cos^2\frac{\phi}{2} = \frac{1}{2} \\ n^2 = 3 & \cos^2\frac{\phi}{2} = \frac{1}{3} \\ n^2 = 4 & \cos^2\frac{\phi}{2} = \frac{1}{4} \end{array}\right\} \quad (1)$$

TABLE III.

PERIOD OF OSCILLATION T.

As a function of the radius of gyration of the weights of the cars.

Type "Patrie" $T = \pi\sqrt{\frac{h}{g}}$

Type "Zeppelin" $T_1 = \pi\sqrt{\frac{\lambda^2}{gh_1}}$

and substituting for h its value as a function of h type "Patrie."

$$T_1 = \pi\sqrt{\frac{h}{gn\cos^2\frac{\phi}{2}}}$$

This relation shows that the two periods are equal when

$$n\cos^2\frac{\phi}{2} = 1$$

and that as $\cos\frac{\phi}{2}$ varies from 1 to 0, T varies to infinity. Hence the "Zeppelin" type has a better statical and dynamical condition than the "Patrie" type.

TABLE IV.

RIGHTING COUPLE—C_2

One has

Type "Patrie" $C_2 = Ph\sin\alpha$
Type "Zeppelin" $C_2' = pl - p_1l_1$

Assume

$$p = p_1$$
$$2p = P$$
$$l = \lambda\sin\left(\frac{\phi}{2} + \alpha\right)$$
$$l_1 = \lambda\sin\left(\frac{\phi}{2} - \alpha\right)$$

$$C_2' = p\lambda\left\{\sin\left(\frac{\phi}{2} + \alpha\right) - \sin\left(\frac{\phi}{2} - \alpha\right)\right\}$$
$$= 2p\lambda\cos\frac{\phi}{2}\sin\alpha$$
$$= P\lambda\cos\frac{\phi}{2}\sin\alpha$$

This expression, compared with the formulæ for the moment of inertia, shows that the "Righting Couples" C_2 and C_2' of the two systems will be equal if

$$\sqrt{\lambda^2\cos^2\frac{\phi}{2}} = h$$

that is to say, in cases when, for example,

$$\left.\begin{array}{ll} \lambda^2 = h^2 & \cos^2\frac{\phi}{2} = 1 \\ \lambda^2 = 2h^2 & \cos^2\frac{\phi}{2} = \frac{1}{2} \\ \lambda^2 = 3h^2 & \cos^2\frac{\phi}{2} = \frac{1}{3} \\ \lambda^4 = 4h^2 & \cos^2\frac{\phi}{2} = \frac{1}{4} \end{array}\right\} \quad \ldots (2)$$

From equations (1) and (2) one gets

$$h_1 = \frac{h}{\sqrt{x}} \quad \ldots \quad (3)$$

$$\lambda = h\sqrt{x} \quad \ldots \quad (4)$$

$$\cos\frac{\rho}{2}=\sqrt{\frac{1}{x}} \quad . \quad . \quad . \quad (5)$$

In conclusion, for conditions of equality of statical stability between the type "Zeppelin" and "Patrie," it is necessary that the angle of divergence of the two cars, and the distance of these cars from F, should satisfy the equations (3), (4), and (5). Further, it is seen from the above that by increasing the angle of divergence of the cars the time of oscillation is reduced.

THE AËRONAUTICAL SOCIETY OF GREAT BRITAIN.

The Aëronautical Society of Great Britain is the oldest institution of its kind in the world, having been founded in January, 1866. At this period a considerable interest was being taken in the subject of ballooning for scientific purposes, Mr. James Glaisher, F.R.S., having already made several sensational ascents for investigating the conditions of the upper air. He was instrumental in founding the Society, and became its Treasurer. The Duke of Argyll was just bringing out his book "The Reign of Law," in which he went deeply into the question of the flight of birds and of the possibility of imitating the action by machinery. So well-known and highly honoured a personage was naturally offered the Presidency of the Society, and he was well backed up by other leading men devoted to science and mechanics, the Duke of Sutherland, Lord Richard Grosvenor, and Lord Dufferin becoming the Vice-Presidents. Hatton Turner's great work, "Astra Castra," well known as the greatest published collection of matter relating to aëronautics, had appeared in the preceding May, and had doubtless added greatly to the public interest in the subject. The author was elected a member of the Council. Other members of the Council included Sir Charles Bright, M.P., F.R.A.S., William Fairbairn, LL.D., F.R.S., and several other well-known engineers.

Mr. Fred Brearey, a keen advocate of the heavier-than-air principle of aërial navigation, was appointed Hon. Secretary. At the end of the first year the membership had reached sixty-five.

The first general meeting of the Society was held on June 20th, at the Society of Arts, in which building its meetings have been held ever since. On this occasion Mr. W. H. Wenham read a paper on "Aërial Locomotion," which to this day remains one of the most instructive of the many which have since been read before the Society. The Annual Report for the year was the first of those which followed regularly for some twenty-five years.

These reports of the Society form a most valuable record of what has been done in England, and to some extent abroad, also, during this period. They contain a number of important papers with interesting discussions, as well as many reprints of older pamphlets, etc., some of which are out of print and almost impossible to obtain.

It may be desirable to briefly recapitulate the more important of these articles:—

During the second year of its existence the Society continued to prosper. Two meetings were held, and in the Second Annual Report it is stated "the Society has good reason for congratulation that since its formation so many fresh minds have been induced to study the question of aerial navigation." The number of members had increased to 91, and in the third year it attained 106.

The Society has held two exhibitions The first was in June, 1868, at the Crystal Palace. It is most interesting now to read the list of exhibits, which is remarkably complete, including 78 entries. Class I. was for light engines and machinery, and the Society offered a prize of £100 for the best exhibit. Several good machines were shown. The account of exhibit No. 7 is specially noteworthy, which was a "WORKING MODEL OF THE BRIGHTON OIL ENGINE. In this engine power is derived from explosion within the cylinder of inflammable gas or vapour mixed with atmospheric air. The vapour is produced by volatilization of certain liquid hydrocarbons." This was one of the first ancestors of the internal combustion engine which has now been the means of practically solving the mastery of the air. Stringfellow's steam engine, however, was the one which carried off the prize of £100. It was of just over one-horse-power, and "the weight of the engine and boiler was only 13 lbs., and is probably the lightest steam engine that has ever been constructed," so the Report tells us.

Class II. was for complete working aërial apparatus; Class IV. for working models, and Class V. for plans and illustrative drawings. Class VII. was for kites.

The second exhibition was in 1885, and was held at the Alexandra Palace. This, however, was not so great a success as the first, although a number of most interesting models were shown.

Meanwhile, in 1871, a series of experiments on air pressure were conducted under the auspices of the Society, special apparatus having been constructed by Mr. Browning and operated by Mr. Wenham, some highly interesting results were obtained and tabulated.

The Society continued its career of usefulness and issued its Reports regularly until about the year 1893, when its activity slackened a good deal. The membership had gradually died down, and Mr. Brearey, the Hon. Secretary, was getting an old man and had lost much of that keen energy which had so successfully stimulated the Society in its early days. Most of the leading lights of the Society had become inactive in their support. Mr. Glaisher, now in his 88th year, was the only original member of the Council remaining, and was unable to render much service.

In 1896 Mr. Brearey died, and though it looked as if the last glow of the dying embers had ceased, yet this really resulted in fresh blood coming forth and re-kindling the fire. In November of that year a meeting of the few remaining members of the Council (including Messrs. E. A. Barry, B. Baden-Powell, E. P. Frost, and Major Roberts) was summoned, when it was decided to endeavour to resuscitate the Society. Events of importance had been going on which had attracted much public attention to aëronautics. Sir Hiram Maxim had been conducting his well-known experiments. Lilienthal in Germany and Langley and Chanute in America had also aroused great interest. So that the time was ripe for action. Captain (now Major) Baden-Powell was appointed Honorary Secretary, and a strong Council, including Sir Edwin Arnold, the Earl of Crawford, Sir William Crookes, F.R.S., Mr. (now Sir) Hiram Maxim, Colonel Templer, and General Sir Charles Warren was formed.

In January, 1897, the quarterly "Aëronautical Journal" was started in place of the Annual Reports, and this has continued to be issued regularly ever since.

In 1899, Major Baden-Powell went off to the war in South Africa, and Mr. E. S. Bruce took his place as Honorary Secretary. Major Baden-Powell was later elected President of the Society.

A number of meetings have been held each year, both for the reading of papers as well as for out-door experiments and competitions. Among the latter may be specially mentioned the International Kite Competition, held on the downs near Worthing in 1903, and a display of apparatus at Sunningdale in 1907. The Society is now in a flourishing condition. Financially, it has recently benefited by the generous donation of £100 annually for five years from Mr. P. Y. Alexander, and last year a grant of £105 was given by the Mercers' Company in aid of research.

A good library has also been formed, which includes almost all the published works on Aëronautics in the English language.

Last year some important changes in the Officers of the Society took place, when Major Baden-Powell retired from the Presidency after seven years of office, and Mr. E. P. Frost was elected to fill the vacancy. Mr. E. S. Bruce also resigned the Honorary Secretaryship, and has been succeeded by Colonel J. D. Fullerton, late R.E.

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NOTES.

Dirigible Balloons.—The May, 1908, number of the Royal Engineer Journal contains an interesting paper by Colonel J. Capper, R.E., C.B., on Dirigible Balloons. The author gives a general account of the construction of the different parts, envelope, system of suspension, etc., with a great deal of general information of a kind likely to be useful to those who contemplate constructing airships of this type.

The "Ripping Cord."—"La Conquête de l'Air," of April 15th, 1908, gives a copy of a letter written by Mons. Jules Verne, describing an ascent made by him, in company with Mons. E. Godard (senior), at Amiens on September 28th, 1893, in the "Meteor" balloon. Describing the balloon and its appurtenances, the writer states: "Une 'corde de fracture' lui permet, au besoin, de fendre son aerostat au cas où le ballon, rasant la terre, demanderait à être instantanément vidé pour la necessité de l'atterrissement."

This is interesting as showing the value put on this kind of apparatus by an expert balloonist.

Foreign Aëronautical Publications.

(In this list a selection of some of the more notable articles only is given.)

The American Aeronaut.

February-March, 1908.—Motor Ballooning.—Farman's Triumph.—Airship Engines.

May, 1908.—Europe's Aërial Navies.—Some of the latest phases of the Flying Machine Sport.—Herring's Work.—The Regulation of Flying Machines.—The "Red Wing."

Aeronautics (America).

April, 1908.—The advantages of the Hélicoptère over the Aëroplane.—The first successful trials of the "Red Wing."—Equilibrium and Control of Aëroplanes.—Construction and Equipment of Wind-Tunnels.—The new Baldwin Dirigible.—Hydrogen for Dirigibles at low cost.—On the use of Liquid Hydrogen, etc.

May, 1908.—The Cornu Hélicoptère.—On the first Observations with Sounding Balloons in America.—On the use of Liquid Hydrogen, etc.

L'Aerophile.

April 1st, 1908.—The Breakage of Screw Propellers at high velocities.—The Starting of Aëroplanes.—The "Kapferer" Aëroplane.—The uselessness of "Level Indicators."

April 15th, 1908.—The Paul Cornu Hélicoptère.—The "Dufaux" Motor.—"Level Indicators."—Aéro-Club of France; a general account of Aëronautical work done in 1907.

May 1st, 1908.—Determination of Geographical Position in a Balloon.—The Brothers Wright; recent patents.—The "Useful" weight which an Aëroplane can lift.—The Aëroplane Roesch-Seux.

May 15th, 1908.—The "Bayard-Clement" Flying Machine.—Equilibrium and Turning.

June 1st, 1908.—The "Forlanini Hydroplane.—"How to increase the Velocity of Dirigible Balloons."—"Concerning Aviation."

Illustrierte Aeronautische Mitteilungen.

April 3rd, 1908.—International Commission for Aëronautical Cartography.—Flight Experiments in Sweden.—The German Aéro-Club.

April 18th, 1908.—On air propellers and hélicoptères.—The Propeller of the "Ville de Paris."

May 3rd, 1908.—The "Ellehammer" Flying Machine.—An Aërodynamical Laboratory.—The Tatorinoff Flying Machine, p. 238.

May 18th, 1908.—The Stability of Flying Apparatus.—The Astronomical Determination of a Balloon's position.

June 3rd, 1908.—The Stability of Flying Apparatus.—The Airship "La France," by Colonel H. W. Moedebeck.

WIENER LUFTSCHIFFER-ZEITUNG.

April, 1908.—The Art of Flying.

May, 1908. — Aërophotography. — The Wels-Etrich Flying Machine.

June, 1908.—The temperature at high altitudes.—On Aëronautical expressions.

LA REVUE DE L'AVIATION.

January, February, March, 1908.—Flying Notes.—Concerning Flight.

April 15th, 1908.—Notes on Lifting Propellers.—Aviation during the month.

SOCIETA AERONAUTICA ITALIANA.

No. 4.—The direction and velocity of the wind in hilly country.—Aëronautics as affecting military operations.—New Aëroplanes.—The United States Military Dirigible.—Light Motors for Aëronautical work.—Scientific Chronicle.

No. 5.—On the Conditions of Equality of Statical Stability between the Dirigibles "Patrie" and "Zeppelin."—Aëronautical Notes.—Scientific Chronicle.—Sporting Supplement.

Applications for Patents.

(*Made in April, May and June.*)

The following list of Applications for Patents connected with Aëronautics has been specially compiled for the AËRONAUTICAL JOURNAL by Messrs. BROMHEAD & Co, Patent Agents, 33, Cannon Street, London, E.C.

APRIL.

6566. March 24th. M. F. GUTERMUTH. Improvements in Wings for flying machines.

6593. March 24th. R. W. WARREN. Improvements in flying machines.

6741. March 26th. J. VRENGDENHILL. New or improved paddle, oar, rudder or helm and the like, for paddle steamers, airships, rowboats, driving or under-water boats and the like.

7129. March 31st. F. CAPONI. Improvements in aeroplanes.

7205. April 1st. M. KAY. Improvements in and relating to aeroplanes and flying machines.

7370. April 3rd. J. SAWARD. Airship.

7632. April 6th. W. S. MIELCAREK. Improvements in airships.

7686. April 7th. J. HOLZINGER. Improved propeller for use in air or water.

7971. April 10th. S. ROGERS and F. M. FOGARTY. Improved propellers for aerial and marine navigation.

8099. April 11th. C. A. CHAPPELL. Improvements in or connected with flying machines, aeroplanes, aerocurves, kites and the like.

8306. April 14th. W. MICHALK. Improvements in aerostats.

8360. April 15th. A. JOUVENEAU. Improvements in or relating to flying machines or the like.

8488. April 16th. F. L. MARTINEAU. Improvements in and relating to aerial machines.

8591. April 18th. A. WORSWICK. Improvements in propellers and wings for aeroplanes and the like.

8627. April 18th. G. W. HART. Improvements relating to the wings of flying machines.

8628. April 18th. A. DEMOULIN. Improvements in and relating to aeroplanes and flying machines.

8643. April 18th. R. ESNAULT-PELTERIE. Improvements in aeroplanes.

8681. April 21st. A. B. MEES. New or improved mechanism for lifting, propelling, and steering in the air.

8842. April 23rd. L. P. SHADBOLT. Improved method of steering an aeroplane.

8844. April 23rd. J. S. JUN. Improvements in and relating to the control of motor propelled vehicles, boats, and flying machines.

MAY.

9513. May 2nd. H. S. BOOTH. Improvements in flying machines.

9799. May 5th. MOTORLUFTSCHIFF STUDIENGES. Safety valve for air balloons.

9898. May 6th. C. R. B. BROWN. Improvement in aeronautical machines.

9970. May 7th. V. HUMBERT. flying machine.

10161. May 11th. J. KAY. Improvements in steadying balloons, also when applicable to airships, flying machines, and the like.

10528. May 14th. R. ESNAULT-PELTERIE. Improvements in aeroplanes.

10801. May 18th. H. E. WILLIAMS. Improvements in and relating to machines used for navigating the air.

10900. May 20th. P. G. C. FU PIETRO. New aeroplane.

11155. May 22nd. H. H. PUFFARD. Improvements in flying machines.

JUNE.

11719. May 29th. W. TARTARENOFF. Improvements in flying machines.

11763. May 30th. W. FAIRWEATHER. Improvements in airships.

11948. June 2nd. V. WISNIEWSKI. Improvements in or relating to airships and flying machines.

12013. June 3rd. J. L. GARSED. Improvements in the method of and means employed for steering aerial machines.

12102. June 3rd. J. MILLER. Improved airship.

12131. June 4th. R. ALLEN. Improvements in and relating to aerial navigation.

12148. June 4th. N. W. AASEN. Improvements in rocket parachutes.

12247. June 5th. A. CLEMENT. Improved dirigible balloon.

13016. June 18th. J. R. PORTER and J. E. MALLINSON. Improvements in and relating to flying machines.